Microbiology
and mycology

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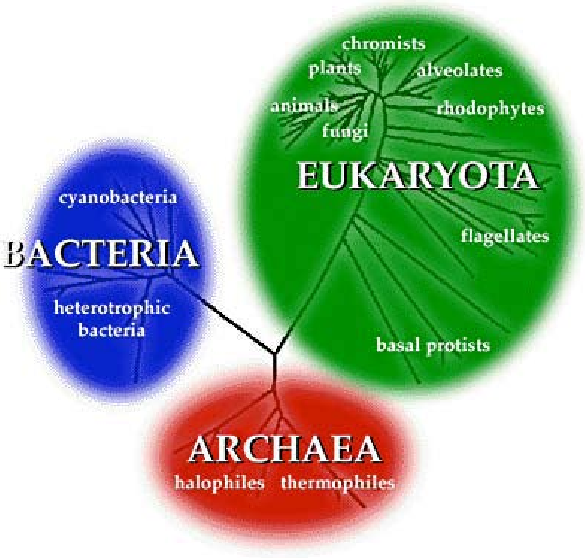
I. Microbiology and mycology

By Prof. Jassiel Nyengani Zulu, University of Zambia, Department of Biological Sciences, Lusaka and Dr. Modest Diamond Varisanga, Open University of Tanzania, Faculty of Science, Technology and Environmental Studies.



The Three Domains of micorbes

Obtained from http://www.ucmp.berkeley.edu/alllife/threedomains.html
On 30/03/2007

II. Prerequisite Courses or Knowledge

In order to be allowed to do this module a learner should have acceptable High School qualifications or its equivalent qualifications for entry into University for Biology Science Education as required by the University. Exemptions may be extended to cases where pre-entry examinations exist, or where in-service Biology teachers are to be considered. Basic knowledge of structure and function of different cell types will be useful in understanding the concepts contained in this Module.

III. Time

120 hours, will be required to complete this module; 80 hours for the part dealing with Bacteria, Viruses and Protozoa and the remaining 40 hours for the part on Mycology.

IV. Material

Access to the following materials is necessary to facilitate the study of this Module:

- A hard copy (print) and electronic materials, including relevant CDs, CD-ROMS, videos, and other related learning aids.
- Relevant reference text books.
- Laboratory equipment such as a microscope, an autoclave, oven, an incubator (various temperatures), Petri plates, materials for bacterial and fungal media preparations, various staining chemicals, identification manuals and other laboratory equipment and materials for standard microbiology work
- Capacity to facilitate for site visits/field trips.

V. Module Rationale

This Module provides a student with basic knowledge of the diversity of microorganisms. These are; bacteria, viruses, protozoa and fungi. Their biology as it relates to their economic importance in the environment are discussed in detail. The theory aspects of the module will be elaborated through relevant laboratory exercises to illustrate the principles and concepts of the subject matter. The knowledge attained will enhance the teacher's ability to teach High School Biology.

VI. Content

6.1 Overview

This Module is a study of organisms that can not be seen with the unaided eye unless with the help of a microscope. They are referred to as microorganisms. More commonly they are called microbes. These are bacteria, viruses, protozoa and fungi. Although viruses are strictly not organisms, they too will be discussed under the same title for convenience. Mycology which is the study of fungi includes some groups like the mushrooms with macroscopic fruiting structures, which appear seasonally above the ground. The study of microbes is called microbiology. The module starts with the history of microbiology; the discovery of microbes and the development of sterile culture techniques, and goes on to explore the diversity of microbes, their major biological characteristics and economic importance. Examples of laboratory exercises meant to familiarise the students with microbiological techniques such as, media preparation, isolation, identification, culture maintenance, growth measurements, staining techniques and preservation are presented wherever applicable.

6.2 Outline

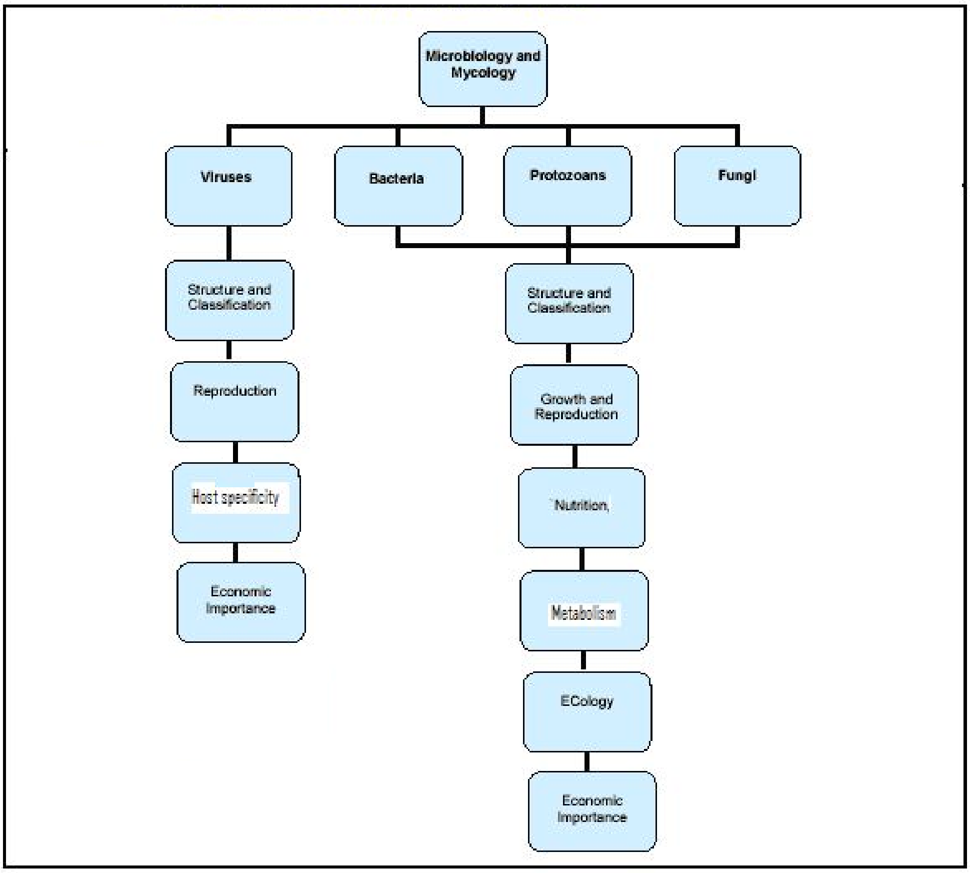
Table 1: Module Coverage and Lecture Schedule

Section	Subsection	Topic	Hours	Practical
6.1		**History of Microbiology**	3	Self study
6.2		**Diversity of microbes**	3	Compare electron micrographs (em) and drawings of typical representatives of each group
6.3		**Bacteria**		
	6.3.1.	Structure, characteristics and Classification	4	Study the drawing of *Escherichia coli* And examine classification cladograms
	6.3.2	Nutrition	4	Prepare a typical bacterial medium
	6.3.3	Growth and reproduction	4	Study growth patterns of different types of bacteria
	6.3.4	Genetics	6	Self study Laboratory activities
	6.3.5	Economic significance Isolation, identification and culture techniques	6	Bacterial effects on plant growth and effect on milk
6.4		**Viruses**		
	6.4.1	Structure and characteristics	3	Study typical drawings of lambda virus
	6.4.2	Classification	4	Compare drawings of different structures of viruses
	6.4.3	Growth and Reproduction	6	Study visit to a virology laboratory
	6.4.4	Economic importance	6	Effects on humans (Human Immuno deficiency syndrome)
	6.4.5	Isolation, culture and identification techniques	4	Study visit to University laboratory for demonstrations

6.5		**Protozoa**		
	6.5.1	Structure and characteristics	6	Comparative pictures and videos
	6.5.2	classification	3	Examine classification cladograms
	6.5.3	Nutrition	4	Examples of malaria parasites
	6.5.4	Growth and reproduction	6	Life cycle of a malaria parasite
	6.5.5	Isolation, culture and identification Techniques	4	Study visit to a research institutes for identification demonstrations
	6.5.6	Significance	4	Example of a malaria parasite
Sub total hours			**80**	
6.6		**Fungi**		
	6.6.1	Structure and characteristics	6	Study visit to a University laboratory to observe prepared slides
	6.6.2	Classification of fungi	6	Study pictures and drawings of various types of fungi
	6.6.3	Identification	4	Study visit to research institutes for identification demonstrations
	6.6.4	Nutrition	6	Study the effects of nutritional deficiencies on fugal growth
	6.6.5	Growth	5	Watch a video demonstrating apical growth in a typical fungus
	6.6.6	Reproduction	5	Pictures and drawings of reproductive structures
	6.6.7	Ecology	4	Study visit to a brewing industry
	6.6.8	Isolation, culture and identification techniques	4	Video show
Sub total hours			**40**	

6.3 Graphic Organizer

Organisation chart of topics covered in the module



VII. General Objective(s)

At the end of this Module, the learner should be able to;

- describe the biology of microbes in terms of their structure and classification, growth patterns and reproduction including their nutritional needs.
- outline the economic importance of microbes.
- describe the different techniques in the isolation, identification, and culture of microbes.
- apply the knowledge acquired from this course in the teaching of Biological Sciences to High School pupils.

VIII. Specific Learning Objectives (Instructional Objectives)

Unit 1: Bacteria

At the end of this unit, the learner should be able to;

1. describe how bacteria were discovered.
2. discuss the development of the culture technique.
3. classify bacteria based on their characteristics.
4. explain the nutritional requirements of bacteria.
5. discuss metabolic activities of bacteria.
6. describe the conditions necessary for optimum growth of bacteria.
7. explain the genetics of bacteria.
8. explain the economic importance of bacteria.
9. demonstrate the techniques used to isolate and stain bacteria.

Solid agar plate with bacterial colonies
http://en.wikipedia.org/wiki/Bacteria
Retrieved on 30/03/2007

Unit 2: Viruses

After going through this unit, the learner should be able to;

1. describe the basic structure of viruses.
2. compare and contrast the structure of viruses with that of bacteria.
3. state the characteristics used to classify viruses.
4. list the taxonomic groups of viruses.
5. explain the process of viral reproduction.
6. perform biological techniques such as primary cell line preparation for viral culture, plaque and quantal assays, methods of counting virions, and hemagglutination.
7. discuss the economic importance of viruses.

Unit 3: Protozoa

After completing this unit, the learner should be able to;

1. classify protozoa according to their taxonomic characteristics.
2. discuss the nutritional requirements of the protozoa.
3. discuss the physiology and metabolism of protozoa.
4. apply the culture technique used to grow protozoa.
5. explain the impact of pathogenic protozoa on humans.

Unit 4: Mycology

At the end of this unit, the learner should be able to;

1. classify fungi based on their characteristics.
2. describe the structure of a typical septate hypha of a fungus.
3. discuss the growth pattern of cellular and mycelial fungi.
4. explain the major types of nutrition among the fungi.
5. illustrate the major types of reproduction systems among the fungi using their life cycles.
6. explain the different modes of nutrition among the fungi.
7. explain the metabolism of carbon in fungi.
8. understand culture preservation techniques.
9. compare and contrast fungi with bacteria.
10. explain the economic importance of fungi.

IX. Teaching And Learning Activities

9.1 Pre-assessment

Microbiology and Mycology

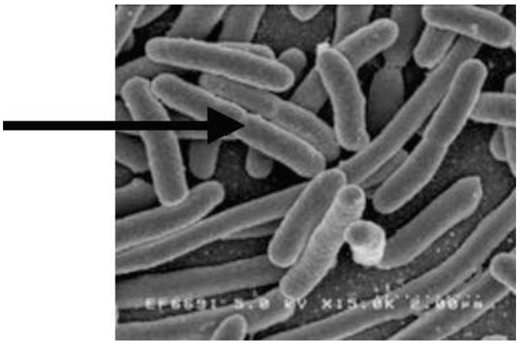
Rationale: This pre-assessment is meant to determine the preparedness of the learner to understand the concepts contained in this module. Apart from assessing the learner's level of knowledge in the field of microbiology and mycology, the assessment will also indicate if there is need for the learner to do further reading before setting out to study the module.

Attempt the following questions and compare your answers with the ones given at the end of the exercise.

Questions

1. The common characteristic of most members of the microbial world is their…
   (a) abundance.
   (b) small size.
   (c) economic importance.
   (d) ability to cause disease.

2. The following electron micrograph illustrates the general morphology of a collection of bacterial cells. Which one of the following groups of bacteria would best describe the organism singled out with an arrow?
   (a) Steptococcu.
   (b) Diplobacillus.
   (c) Streptobacillus.
   (d) coccus



http://en.wikipedia.org/wiki/Bacteria
Retrieved on 28th of March 2007.

3. An antigen is a substance that…

   (a) is produced by the bacteria to keep other microbes away.
   (b) forms complementary reactions for the survival of bacteria.
   (c) elicits the production of specific antibodies.
   (d) bacteria use for digestion of other organisms.

4. The person best known for his microscopy work on microorganisms is…

   (a) Antony van Leeuwenhoek.
   (b) Louis Pasteur.
   (c) John Tyndall.
   (d) Darwin.

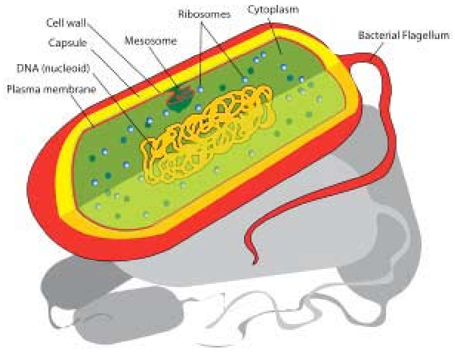
5. The simple staining technique in bacteriology is frequently used to ...

   (a) differentiate between bacterial classes or groups.
   (b) determine the size, shape and arrangement of bacteria.
   (c) demonstrate rickettsias located within the host cells.
   (d) identify disease causing bacteria.

6. Microbial growth is measured by …

   (a) an increase in the number of cells in a population.
   (b) the amount of heat produced by the organism in culture.
   (c) the type of toxin produced by the microbe.
   (d) the size of the cells in a population.

7. What anatomical characteristic shown in the electron micrograph could be used to classify the organism as a prokaryote?



http://en.wikipedia.org/wiki/Bacteria
Retrieved on 28th of March 2007.

The presence of …

(a) nuclear material not contained in a membrane.
(b) a well defined flagellum.
(c) a cell wall.
(d) a plasma membrane.

8. The 'titer' of the virus, or the 'endpoint', is the dilution at which … of the inoculated hosts are affected or killed.

(a) 100%
(b) 80%
(c) 50%
(d) 10%

9. Nucleoids are associated with…

(a) viruses.
(b) genetic information.
(c) prokaryotes.
(d) fungi only.

10. Bacteria that obtain their energy from inorganic compounds containing iron, nitrogen, or sulphur and not from decaying organic matter are …

(a) chemolithotrophic.
(b) heterotrophic.
(c) autotrophic.
(d) parasitic.

11. The presence of viruses in the blood stream is referred to as…

(a) cell tropism.
(b) a monocytic condition.
(c) viremia.
(d) viral contamination.

12. Each virus particle, is called a … when it is on the outside of its host cell.

(a) virion
(b) capsid
(c) phage
(d) nucleoid

13. The shape of a virus is determined by the…
    (a) nucleocapsid that forms its head.
    (b) type of nucleic acid it contains.
    (c) shape of the capsid protein.
    (d) number of nucleic acids in the cell.

14. The protists are of medical importance because…
    (a) several cause diseases in humans.
    (b) some are used in the manufacture of antibiotics.
    (c) protists enter symbiotic relationships with many organisms.
    (d) some are used for the manufacture of soap.

15. An example of the phylum Rhizopoda is …
    (a) *Paramecium* spp.
    (b) *Amoeba proteus*.
    (c) *Plasmodium vivax*.
    (d) *Escherichia coli.*

16. Which of the following pairs of words is **mismatched**?
    (a) *Plasmodium vivax* – malaria.
    (b) *Amoeba* spp.– severe diarrhea.
    (c) AIDS – *Giardia lamblia.*
    (d) *Escherichia coli* – tuberculosis.

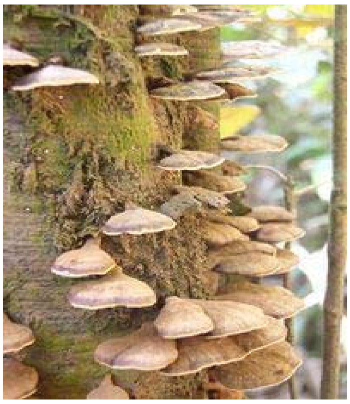
17. The phylum Sarcomastigophora …
    (a) consists of intracellular parasites.
    (b) includes both flagellated and amoeboid parasites.
    (c) is composed of ciliated parasites.
    (d) comprises amoeboid parasites only.

18. Which of the following illnesses is caused by zooflagellates?
    (a) Giardiasis, leishmaniasis, sleeping sickness
    (b) Trichomoniasis, malaria, lambliasis
    (c) Flagellate diarrhea, embadomonas, leishmaniasis
    (d) Flagellate diarrhea, lambliasis, leishmaniasis.

19. Fungi are classified according to…
    - (a) the type of conidia produced
    - (b) their mycelial resemblance.
    - (c) their morphological similarities.
    - (d) similarity in their growth patterns.

20. One group of fungi is called the ‘Imperfect fungi’. What does the term mean?
    - (a) Fungi that do not produce a zygospore in their life cycle.
    - (b) Fungi in which sexual reproduction has not been observed.
    - (c) Fungi that cause diseases.
    - (d) Fungi that demonstrate both asexual and sexual reproduction.

21. Study the organisms growing out of a tree trunk very carefully and answer the question that follows.



http://en.wikipedia.org/wiki/ungus
Retrieved on 28/03/2007

The organism shown in the picture is …
- (a) an Ascomycete.
- (b) a Zygomycete.
- (c) a Basidiomycete.
- (d) an Oomycete.

22. The following picture illustrates blue cheese that is veined with a fungus called *Penicillium roquefori.*

http://en.wikipedia.org/wiki/Ascomycota
Retrieved on 28/03/2007.

What message does the picture above get across?

(a) Fungi play an important role in the processing of food.
(b) Food infected by fungi is rendered unpalatable.
(c) All food types that are infected with a fungus go to waste.
(d) Cheese gets easily infected with fungi.

Pre-assessment Answer Key

1. (b) is their small size
2. (b) Diplobacillus
3. (c) that elicits the production of specific antibodies
4. (a) Antony van Leeuwenhoek
5. (b) determine the size, shape and arrangement of bacteria
6. (a) is an increase in the number of cells in a population
7. (a) nuclear material not contained in a membrane
8. (c) is the dilution at which 50% of the inoculated hosts are affected or killed
9. (b) genetic information
10. (c) autotrophic chemolithotrophic
11. (c) viremia
12. (a) virion
13. (c) the shape of the capsid protein
14. (a) several cause diseases in humans
15. (b) *Amoeba proteus*

16. (c) AIDS – *Giardia lamblia*
17. (b) includes both flagellated and amoeboid parasites
18. (a) giardiasis, leishmaniasis, sleeping sickness.
19. (a) the aspects of their sexual life cycle
20. (b) sexual reproduction has not been observed
21. (c) Basidiomycete
22. (a) Fungi play an important role in the processing and production of food such as cheese and yoghurt.

Microbiology and Mycology Pre-assessment

This pre-assessment is drawn from Advanced High School Biology content. If you score 60% and below, it is recommended that you do more relevant reading to familiarize yourself more with the contents of this Module. The following are some of the website pages that will enhance your understanding of some of the concepts covered.

X. Learning Activities

Title of Learning Activity: **Elements of Bacteriology**

Summary of the Learning Activity

In this activity, you will learn about the history of microbiology and appreciate the discoveries of microbes, microscopes and the development of the sterile culture technique. Microorganisms are quite diverse in their distribution, appearance, physiology and metabolism, including their genetics. Bacteriology is a branch of microbiology, which deals with bacteria, which can be classified on the basis of their structure, cellular metabolism or differences in their cellular chemistry. However, classification based on these parameters has limitations in use as a difficulty arises whether the separation of bacteria is between species or between strains of the same species. A more reliable form of bacterial classification uses molecular systematics based on genetic techniques. As a result of this work prokaryotic microbes are taxonomically divided into two groups called **Bacteria** and **Archaea**, having evolved independently from a common ancestor. Some characteristics of bacteria such as high reproductive rates, ability to colonise extremes of environmental conditions and the formation of weather resistant structures such as endospores make bacteria a highly successful group of organisms. Bacteria use flagella to move about in the environment. They need a film of water to achieve this. Some mutualistic bacteria have the capacity to use butyric acid or propionic acid in the environment emitting hydrogen as a by product, which Archaea assimilate for their metabolic reactions. Otherwise the hydrogen would accumulate in the environment and the bacteria would not survive. The human gut carries thousands of species of bacteria as symbionts. The gut flora is useful as it enhances gut immunity, contributes to production of vitamins, helps to convert milk protein to lactic acid including assisting with the fermentation of otherwise indigestible complex carbohydrates. Some soil bacteria can convert atmospheric nitrogen into nitrogenous compounds creating a form of nitrogen that can easily be absorbed by plants, which can not fix nitrogen themselves. Bacteria also exhibit a parasitic mode of existence, when they cause disease in humans such as typhoid fever, tuberculosis, etc, leading to many deaths. Bacteria also cause disease in plants resulting in tones of annual crop losses in the agricultural industry. Bacteria have also been deliberately exploited by humans in a number of beneficial ways, despite the fact that they can be harmful. Therefore, Bacteria have had, and continue to have, an enormous impact on life on the planet earth. They are a virtue as well as a curse.

The knowledge gained from the literature will be supported when you can visit a number of institutions and organisations that culture or work with microorganisms such as water treatment plants, waste treatment plants, research centres, hospitals and the like. Your study visit will be followed by submission of a report on the visit. Record your observations and relate your experiences to the theoretical foundations from the literature review.

Key concepts

Bacteriology: A branch of microbiology which deals with the study of bacteria.

Endospores: Highly resistant dormant structures formed by certain genera of Gram-positive bacteria such as *Bacillus, Clostridium*, etc.

Plasmids: Small DNA fragments found in some bacterial cells. Plasmids sometimes carry genes for resistance to antibiotics.

Conjugation: One of the genetic recombination, where one bacterium passes DNA to another through a tube (the sex pilus) that joins the two temporary joined cells.

Chemostat: A device used in a continuous culture of bacteria so as to maintain a bacterial population at a constant density in a situation that is, in many ways, similar to bacterial growth in natural environments.

Microscopy: Any technique that uses a microscope or any other tool for producing visible images of structures or details too small to be seen by the human eye.

List of relevant readings

Alcamo, I. E. 2001. Fundamentals of Microbiology. 6th ed. Menlo Park, California: Benjemin Cumming. Fundamentals of Microbiology. Sounders College Publishing, West Washington Square, Philadelphia, PA 19105.

Frobisher, M., Hinsdill, R.D., Crabtree, K.T. and Goodheart, C.R.1974.

Nester, E.W., Anderson, D.G., Roberts (Jr), C.E., Pearsall, N.N. and Nester, M.T. 2001. Microbiology: A Human Perspective. McGraw-Hill Companies, Inc.

Schopf, J.W. 1999. Cradle of Life: The Discovery of earth's Earliest Fossils. Princeton University Press, 367 p.

http://www.wikipendia.org/wiki/Microbiology

http://en.wikipendia.org/wiki/Bacteria

http://gsbs.utmb.edu/bacteria/bacteria.html

http://www.emc.maricopa.edu/faculty/farabee/BIOBK/BioBookDiversity 2.html

http://www.wikipendia.org/wiki/Microbiology

http://www.stlcc.cc.mo.us/fp/users/kkiser/History.page.htm

List of optional readings

Blake, L. *et al.* 2002. Biology 12. McGraw-Hill Ryerson Ltd.

Mader, S.S. 2004. Biology. McGraw-Hill Companies, Inc., 1221 Avenue of the Americas, NY 10020.

http://www.cbs.dtu.dk/staff/dave/roanoke/genetics980309.html_Accessed on 06/04/2007.

List of relevant useful links

http://www.slic2.wsu.edu:82/hurlbert/micro101/pages/101hmpg.html

http://www.ucmp.berkeley.edu/bacteria/bacterialh.html

http://en.wikipedia.org/wiki/Microscopy

http://en.wikipedia.org/wiki/Category:Laboratory_techniques

http://en.wikipedia.org/wiki/Category:Microbiology_techniques

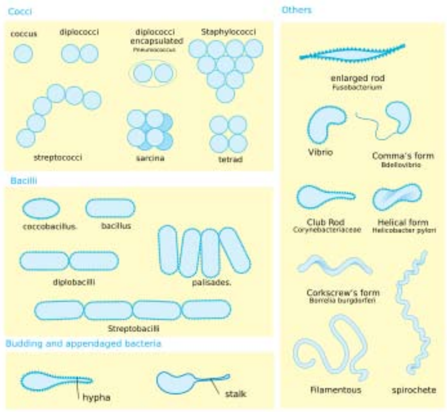
http://en.wikipedia.org/wiki/Deer_Island_Waste_Water_Treatment_Plant

http:bact.wisc.edu/Microtextbook/index.php?module=Book&func=displayarticle cle&a rt_id=25

Detailed description of the learning activity

In this activity, you will learn that *micro* means very small, and *biology* is the study of living things. Therefore, Microbiology is the study of small life forms called microorganisms or *microbes.* They are too small to be seen by the human eye. The science of microbiology started with the invention of a single lens microscope designed by Antonie van Leeuwenhoek in 1676. The discoveries of sterile culture conditions can be traced to the works of Robert Kock (1843 – 1910) who invented methods to purify the bacillus from blood samples and grew them in pure culture on bacterial growth media. Together with his coworkers Kock invented the Petri dish which was named after his assistant Julius Richard Petri. The culture techniques including the sterilization technique using heat which he encouraged as a way of maintaining sterile conditions contributed immensely and positively to the study and growth of microbiology. It is worth mentioning that Koch is also famous for the Koch's postulates which state that; 'to establish that an organism is the cause of a disease, it must be; in all cases of the disease examined, prepared and maintained in pure culture, capable of producing the original infection even after several generations in culture, and be retrievable from an inoculated animal and culture again. Read the following website reference so that you can get more details about the history of microbiology and its techniques (http://en.wikipedia.org/wiki/Robert_Koch). The study of microbiology is broad and encompasses the study of many diverse organisms, which include bacteria, viruses, protozoa, algae, fungi and multicellular parasites.

Make reference to the following website to learn about the morphology of bacteria. (http://en.wikipedia.org/wiki/Bacteria#Morphology#Morphology). Bacteria vary a lot both in size and shape. They measure between 0.5-5.0 micrometers. Typically bacteria have one of the three shapes; rods (bacilli), spheres (cocci) or spiral (spirilla). However, the rod shaped one can be further divided into three groupings. Vibrios are curved on comma shaped, others are spirilla when they are spiral in shape and yet others are spirochaetes when they are tightly coiled. Using the same website you learn that a typical bacterial cell has an outer coat called a capsule followed by a cell wall. Inner to the cell wall is the plasma membrane, which presses against the cytoplasm. The cytoplasm contains ribosomes, plasmids and nucleic acid in the form of circular DNA. The distinguishing feature about prokaryotic cells is that their nucleic acid is not enveloped in a membrane. Bacteria have a whiplash flagellum and much shorter projections called pilli on the outer surface of the cell. These structures aid the organism to move about in the environment. Bacteria lack most of the eukaryotic organelles. Electron transport occurs across the cell membrane between the cytoplasm and the periplasmic space.



Bacteria display a large diversity of morphologies and arrangements

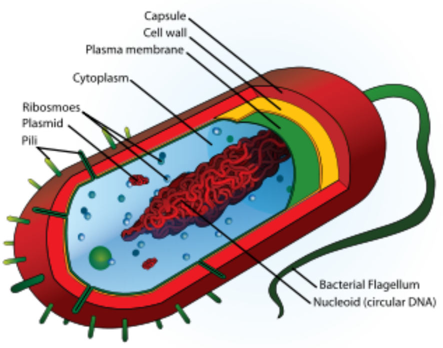


Diagram of the cellular structure of a typical bacterial cell

http://en.wikipedia.org/wiki/Bacteria
Accessed on 19/03/08

Growth, which is an increase in the number of cells, is achieved by cell division. A bacterial cell grows up to an optimum size and then duplicates by binary fission. This can also be regarded as a means of asexual reproduction for bacteria. Given optimum growing conditions bacteria can multiply exponentially.

The genetics of bacteria is centered on a single circular chromosome. Plasmids are extra chromosomal DNA material that may contain genes for antibiotic resistance or indeed factors for virulence.

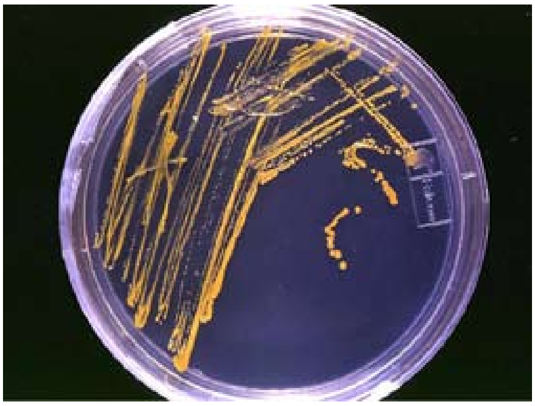
Movements in bacteria take different forms. Bacteria use their flagella or pili for movement. Motile bacteria can be attracted or repelled by external stimuli. An example of this is chemotaxis whose details you can look up under the following reference (http://en.wikipedia.org/wiki/Chemotaxis).

Metabolism in bacteria is calssified on the basis of the type of energy (phototrophy, the use of light through photosynthesis or chemotrophy, the use of chemical substances for energy) used for growth, the type of carbon source (heterotrophic or autotrophic) used and the type of electron donors (lithotrophs use chemical donors while organotrophs use organic compounds donors) used for growth. Detailed reading can be accessed using the following website; http://en.wikipedia.org/wiki/Bacteria

Bacteria can survive bad weather and other environmental hazards through the development of endospores. They have a rigid and impermeable coat with cytoplasm, which contains DNA and ribosomes at the center. They can lie dormant for millions of years before they can become active again (http://en.wikipedia.org/wiki/Bacteria) under favourable conditions.

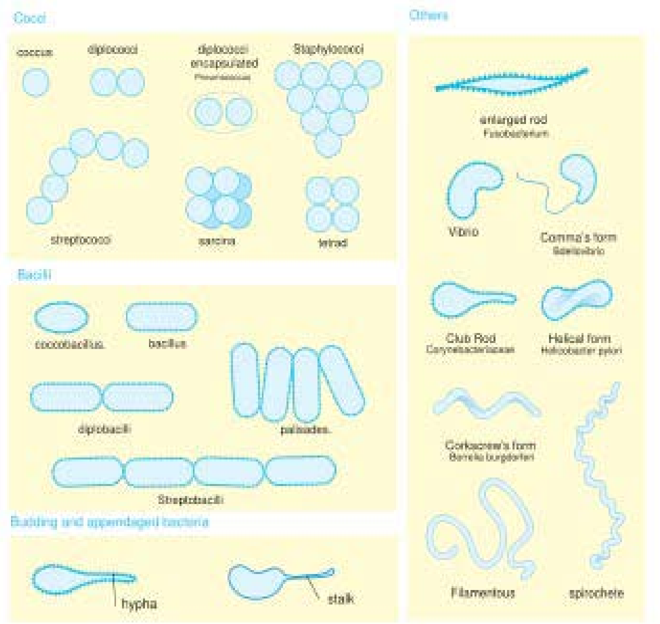
The economic importance of bacteria includes both their useful and harmful aspects in areas of medicine, agriculture and biological studies such as genetic engineering. You can look up the website (http://en.wikipedia.org/wiki/Bacteria) for more details.

The study of bacteria requires knowledge and understanding of how bacteria are grown in culture under laboratory conditions away from their natural habitats. To satisfy this it is important to know how to prepare nutrient media for various fungi. Extensive research has determined the nutritional requirements of bacteria, and this information has resulted in the development of numerous growth media for their cultivation. The most common growth media for microorganisms are liquid media called, broth media and solid media called agar plate media. Refer to the website (http://en.wikipedia.org/wiki/Growth_medium) for details of types of bacterial growth media.



http://en.wikipedia.org/wiki/Growth_medium
Accessed on 22/03/2008

An agar plate is an example of a bacterial growth medium. Specifically, it is a streak plate. The orange lines and dots are colonies of bacterial growth.



Bacterial diversity of cell morphologies and arrangement
http://en.wikipedia.org/wiki/Ascomycota
Retrieved on 28/30/2007.

The study of bacteria requires good working knowledge of a microscope as the cells of bacteria are beyond the human eye. A microscope enlarges an image for the human eye to be able to see the details, which would otherwise not be possible. Therefore make reference to the following website (http://en.wikipedia.org/wiki/Microscopy) for more information.

Learning Activities

Readings: You are required to read the following references:

- http://www.emc.maricopa.edu/faculty/farabee/BIOBK/BioBookDiversity 2.html
- http://en.wikipendia.org/wiki/Bacteria
- http://en.wikipedia.org/wiki/Microscopy
- http://en.wikipedia.org/wiki/Category:Laboratory_techniques
- http://en.wikipedia.org/wiki/Category:Microbiology_techniques
- http://en.wikipedia.org/wiki/Deer_Island_Waste_Water_Treatment_Plant
- Frobisher, M., Hinsdill, R. D., Crabtree, K. T. & Goodheart, C. R. 1974. *Fundamentals of Microbiology*. Nonth Edition. Philadelphia: Saunders College Publishing.
- Any other Microbiology book, including those cited in this Module.

These readings will provide you with an overview on the historical perspectives and discoveries that contributed to the study of microbiology, bacterial morphology, classification, physiology and economic importance.

Write a brief summary of about 100 words on each of the following items:

1. Discoveries of microbes and microscopes.
2. The main features for classification of bacteria
3. Selective media for bacteria
4. Asexual and sexual reproduction in bacteria.
5. Bacterial Genetics
6. The importance of bacteria in the environment, food industry and agriculture

Laboratory Practical

Practical skills are mandatory for this Module. You are therefore required to attend laboratory practical exercises in a central laboratory where you will be closely supervised. The practical part of this course will provide you with exercises that reflect the importance of microorganisms in the environment. Be advised that although the organisms selected for various experiments are not known pathogens, it is important to realize that any organism should be handled with care because its potential to be pathogenic might be unknown. Hence, it is vital that before you learn the basic techniques necessary for conducting experiements in a microbiology laboratory you should understand some strict rules and regulations used to ensure safety in the laboratory.

A number of laboratory exercises can be carried out in microbiology. These may include; microscopy, aseptic techniques, bacterial distribution in defferent environments, pure culture techniques using selective media, making a simple smear stain, Gram stain, etc. For care and use of a microscope, you may visit the website (http://www.slic2.wsu.edu:82/hurlbert/micro101/pages/101lab1.html (Accessed on 18/04/2007) for more information . Below is an example of a laboratory exercise:

Title: Culture of bacteria and their characteristics

You are required to take samples of water, soil, spoiled food including any such environment of interest. Study the morphological diversity of bacteria using agar plates. Use different staining techniques to identify the gram positive and gram negative bacterial types.

Materials: Microscope, slides, variety of nutrients, culture plates, incubator, clean bench, Pasteur pipette, sample slides, alcohol, autoclave, Laminar flow cabinet, inoculating loops, source of flame for sterilization of materials, cotton wool, mutton cloth, muslin cloth, different bacterial stains.

Procedure: Methods for the following activities should be learned; isolation, purification, identification, staining and culture maintenance.

Report: Depending on the type of task assigned, you may be required to prepare a report either from a particular reading, laboratory exercise or a study visit. Usually the instructor will advise you on the format of the report. However, most scientific reports use the following format:

1. **Title**: The title should be concise. It is a summary of the body of work that covers the contents of the task under investigation.
2. **Introduction**: A brief statement of the background to the subject, its importance and justification for the study.
3. **Objective(s)**: A statement of the main expected outcomes (achievements) from the study.
4. **Methods**: An explanation of the details of how the objectives are going to be achieved. This is important because someone else should be able to use the description of your methods in order to repeat the outcomes of your work
5. **Results**: Results are better presented in form of pictures, tables, graphs, or charts. These should carry a short and clear title, with a description of the results.
6. **Discussion**: An opportunity is provided for the interpretation of results focusing on the objectives. Comparisons and similarities in the results with other published works are discussed and acknowledged.
7. **Conclusions**: A statement is made as to whether the objectives of the exercise had been achieved.

8. **Recommendations**: Suggestions are made about what needs to be investigated further arising from some inconclusive results from the work.
9. **References**: all references used in the write up should be acknowledged in this part using an accepted international format.

Study visits/Self Studies

It is important that either in groups or as an individual, you undertake some study tours to different sample collection sites for the study of bacteria in different ecological habitats. Plan a visit or two to industries where the removal of microorganisms from the environment or the inclusion of microorganisms in the cultivation of food proucts is the prime focus in the organization. The following work centers should be considered depending on the proximity of the industrial activity to your place of residence:

1. An Agricultural College to focus on the importance of micoorganisms in the nitrification process of the soil (legume farm) as well as the pathogenic properties of microorganisms on cash crops (plant protection unit) destructive to farming andrelated activities.
2. Water Treatment Plants as well as Wastewater Disposal Plants to study how drinking water is kept free of microbes (purification plants) and how waste water is disposed off respectively. As an example you can read about The Deer Island Waste Water Treatment Plant (also known as Deer Island Sewage Treatment Plant) run and operated by The Massachusetts Water Resources Authority at the website http://en.wikipedia.org/wiki/Deer_Island_Waste_Water_Treatment_Plant; retrieved on the 01/04/2007.

Objective: The objective(s) of the study visits are to study the;

1. importance of bacteria in agriculture.
2. significance of water purification for home consumption.
3. importance of proper waste water management
4. effect of pathogenic bacteria on cash crops and dairy.

Procedure: This will also depend on the objective of the visit itself

Report: You will be required to write a report on the activities of your study tour. Whenever applicable, specific methods employed should also be described. Your report should follow the same format described under report writing of the section under 1.2 titled Laboratory Practical.

Assignment

1. **Question:** Write a brief essay (500-800 words) on the importance of bacteria in medicine, agriculture and water quality.

Answer framework: In your essay, you may start with a description of what bacteria are, their distribution in the environment and a discussion with given examples of the effects bacteria have in the fields of medicine, agriculture, and genetic engineering.

2. **Question:** Briefly describe the methods of measuring bacterial growth.

Answer framework: Here you may need to describe the two major methods: methods for measurement of cell mass (physical measurement of dry weight or volume after centrifugation; chemical measurement of chemical components like nitrogen or DNA; indirect measurement of chemical activity such as rate of carbon dioxide production; or use of optical density). The other methods are those for measurement of cell numbers (direct microscopic counts; electronic counting chambers; and indirect viable cell counts or plate counts).

3. **Question:** Explain, with the aid of a diagram, a typical bacterial growth curve.

Answer framework: A typical bacterial growth curve is represented in the figure bellow. When bacteria are grown in a closed system (also called a batch culture), like a test tube, the population of cells almost always exhibits these growth dynamics. These are; the **lag phase** (A) when cells initially adjust to the new medium until they can start dividing regularly by the process of binary fission, the **exponential phase** (B) when the cell population grows logarithmically, the **stationary phase** (C), when cell growth becomes limited by the presence of secondary metabolites and or the depletion of nutrients in the growth medium and the **decline phase** (D) when cells stop dividing. Note the parameters of the x and y axes. Growth is expressed as change in the number of viable cells over time. The parameter that gets manipulated in an experiment, which is the variable is placed along the x-axis while the outcome of the experiment is shown along the y-axis.

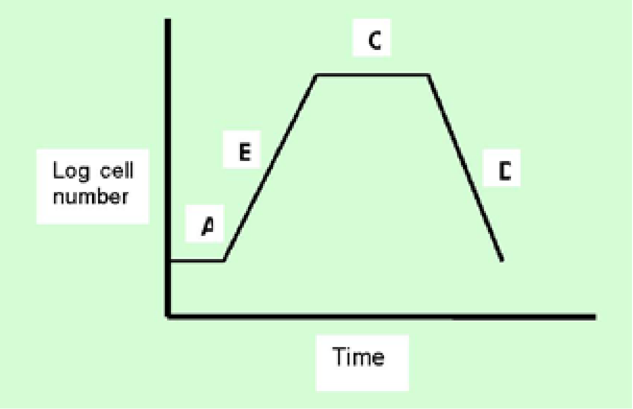


Figure: Typical bacterial growth curve of a batch culture

Formative evaluation:

Attempt the following questions, which are aimed at testing your comprehension of this learning activity.

1. Give a description of each of the following terms.
    - Transcription.
    - Plasmid.
    - Biosecurity.
    - Endospore.
    - Megnetosome.
    - Antibiotic.
    - Fimbrae.
    - Pilus.

2. Write short answers to each of the following:
    - Describe a pure culture.
    - Describe a plaque.
    - Explain the significance of magnification in biology.
    - Give at least four examples of how bacteria are significant to humans?.
    - Define chemostat.
    - What are pathogenic bacteria?
    - Explain the Gram stain technique
    - How do bacteria spoil food?

3. Classifying bacteria on the basis of their morphology is extremely difficult. Explain.
4. Describe the morphologial shapes of bacteria.
5. Describe the factors that affect bacterial growth.
6. Outline the classification of bacteria based on morphology and staining.
7. Explain why obligate anaerobes are significant to the canning industry.
8. Differentiate between:
    - Mesophile and thermophile.
    - Preservation and pasteurisation.
    - Sporulation and germination.
    - Selective medium and differential medium.
9. Describe how you would determine if bacteria are sensitive to an antibiotic.
10. Explain what occurs during each of the four phases of bacterial growth.

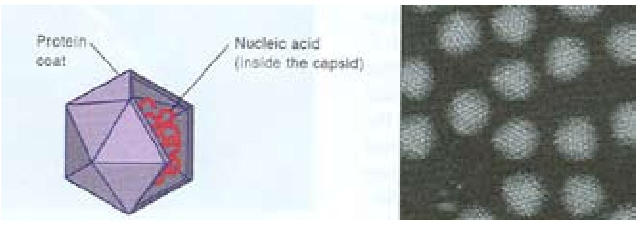
Learning Activity # 2

Title of Learning Activity: **The Study of Viruses**

Summary of the Learning Activity

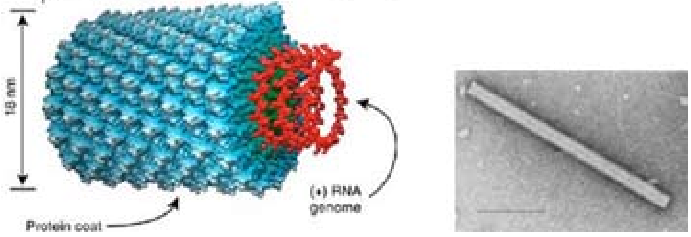
In this activity you will learn that viruses are clearly much smaller in size than most bacteria. They possess characteristcs that are different from bacterial cells. While bacteria are living organisms, viruses are non-living agents or particles that can infect all forms of life, including members of the Bacteria, Archaea and Eukaryotes. Different viruses have different shapes. Some are isometric or rod-like and others are helical. Viruses contain either the ribonucleic acid (RNA) or deoxyribonucleic acid (DNA), but never both, hence they are referred to as either DNA or RNA viruses. Virus classification is based on the genomic structure (RNA or DNA), particle structure and the presence or absence of a viral envelope. In this activity, you will learn about the different taxonomic groups of viruses, their methods of cultivation, quantification (assay) techniques, their reproduction and finally economic importance. A number of website references have been included for your perusal. All of them deal with the structure and functions of viruses. Access the website on the usefulness of bacteria to humans? http://en.wikipedia.org/wiki/Virus to learn more about viruses.

Different structures of viruses



Drawing Electron micrograph

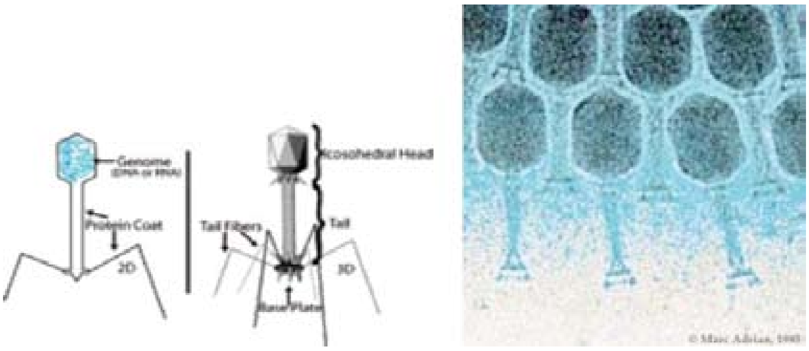
(a) Isometric (adenovirus)



Drawing Electron micrograph

(b) Helical (tobacco mosaic virus)

http://images.google.com/images?gbv=2&svnum=10&hl=en&sa=X&oi=spell&resnum=0&ct=result&cd=1& q=tobacco+mosaic+virus&spell=1
Accessed on 14/04/2007



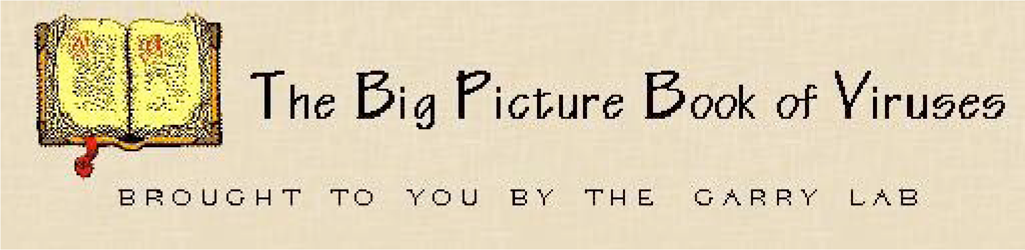
Drawing

Electron micrograph

(c) Complex (T4 bacteriophage)

http://www.wikipedia.org/wiki/Virus≠Structure
Accessed on 14/04/2007

The website http://en.wikipedia.org/wiki/Capsid, accessed on the 02/04/2007 illustrates and describes the different types of viruses with clarity. The introductory section of the webpage explains the general characteristics of viruses.


The Big Picture Book of Viruses
BROUGHT TO YOU BY THE GARRY LAB

Visit the following site that will provide you with the Big Picture Book of Viruses. It can be retrieved from http://www.virology.net/Big_Virology/BVFamilyGenome.

html.

Key concepts

Bacteriophage: Viruses that infect bacteria ('phago' means 'to eat'). Bacteriophages have been studied extensively since bacteria affected by them could be cultivated much more readily.

Virion: A virus particle when it is on the outside of its host cell, and consists of either DNA or RNA surrounded by a protective cover called **capsid**.

Nucleocapsid: The viral capsid together with the nucleic acid that is tightly packed within the protein coat.

Cytopathic effect: Are characteristic changes of the cells' appearance observed in tissue culture cells when they are attacked by viruses. It is one of the methods used to identify viruses in cultured cells.

Titer: The titer of the virus, or the endpoint, is the dilution at which 50% of the inoculated hosts are infected (**ID50**, infective dose) or killed (**LD50,** lethal dose).

Hyperplasia: Is excessive cell division or the growth of abnormally large cells, resulting in the production of swollen or distorted areas of the organism.

List of relevant readings

Frobisher, M., Hinsdill, R.D., Crabtree, K.T., and Goodheart, C.R.1974. Fundamentals of Microbiology. Sounders College Publishing, West Washington Square, Philadelphia, PA 19105.

Nester, E.W., Anderson, D.G., Roberts (Jr), C.E., Pearsall, N.N., and Nester, M.T. 2001. Microbiology: A Human Perspective. McGraw-Hill Companies, Inc.

Radetsky, Peter. 1994. The Invisible Invaders: Viruses and the Scientists Who Pursue Them. Backbay Books.

http://www.wikipedia.org/wiki/virus (Accessed on 01/04/2007).

http://www.virology.net/Big_Virology/BVHomePage.html -Book of Viruses. Accessed on 01/04/2007.

List of optional readings

Blake, L. *et al.* 2002. Biology 12. McGraw-Hill Ryerson Ltd.

Mader, S.S. 2004. Biology. McGraw-Hill Companies, Inc., 1221 Avenue of the Americas, NY 10020.

List of relevant useful links

http://www.wikipedia.org/wiki/virus

http://www.microbiologytext.com/index.php?module=Book&func=toc&book_id=4

http://www.virology.net/Big_Virology/BVHomePage.html

Detailed description of the learning activity

In this activity you will learn that viruses posed a mystery to scientists as recently as 50 years ago, and studies on viruses were carried out using viruses that infected bacteria (so called ***bacteriophage*** or ***phage***). Go to http://en.wikipedia.org/wiki/Bacteriophages to learn more about bacteriophages. According to this website (accessed on the 2/4/2007) a large diversity of phage structures and functions exist. Since viruses are nonliving, they are commonly referred to by the organisms they infect; and each virus particle, often called a ***virion***, consists of nucleic acid (DNA or RNA) surrounded by a protective protein coat, the *capsid* (see http://en.wikipedia.org/wiki/Capsid, retrieved on the 2/4/2007*)*. The most widely used classification criteria for animal viruses are based on a number of characteristics: i) genome structure, ii) particle structure, and iii) presence or absence of viral envelope. Based on these criteria, animal viruses are divided into a number of families, whose names end in –viridae (14 families of RNA-containing viruses and 7 families of DNA-containing viruses). Other non-taxonomic groupings of viruses include; animal, plant or bacteria-infecting viruses. The groupings are based on the route of transmission (enteric, respiratory, sexually transmitted, etc).

The primary difficulty in studying animal viruses is not so much in purifying the virions as it is in obtaining enough cells to infect the host tissue. Some viruses can only be cultivated in the living tissues of animals. Others may be grown in *embryonated chicken eggs*. When animal viruses can be grown in isolated animal cells, the host cells are cultivated in the laboratory by a technique called ***cell culture*** or ***tissue culture***. In order to quantify the amount of virus present in any sample, the method commonly used is known as the ***plaque*** essay. A number of other methods can be used for quantifying the number of virions in a sample. These include the ***counting*** of virions using an electron microscope, ***quantal*** essays, and in the case of some animal viruses, the ***hemagglutination*** method is used.

Viruses are intracellular obligate parasites, which means that they cannot reproduce or express their genes without the help of a living cell. The process of reproduction in viruses is divided into five stages as follows; attachment (adsorption), penetration, replication, assembly and release.

Viruses attack a number of plants and animals, causing enormous economic loss. For example, the website http://en.wikipendia.org/wiki/PorcineReproductive and Respiratory Virus explains how the Porcine Reproductive and Respiratory Syndrome Virus (PRRSV) has caused enormous financial and economic losses in the USA.

There are several possible consequences to a cell that is infected by a virus, and ultimately this may determine the pathology of a disease caused by the virus. However, viruses are also beneficially used in the production of vaccines, as gene carriers in the production of genetically modified organisms, and other molecular studies of a cell.

Virus infections of plants might result in effects such as growth retardation, distortion, mosaic patterning on the leaves, yellowing, or wilting.

http://images.google.com/images?gbv
Accessed on 14/04/2007

Learning Activities

Readings: For this activity you have to read the following references:

Gelderblom, H. R. (1996). Structure and Classification of Viruses in Medical Microbiology *4th ed.* Samuel Baron eds. The University of Texas Medical Branch at Galveston (see reference: http://www.ncbi.nlm.nih.gov/books/bv.fcgi?=mmed.chapter.2252)

Prescott, L. (1993). Microbiology, Wm. C. Brown Publishers.

Villarreal, Luis P. (2005). “Viruses and the Evolution of Life.” Washington, ASM Press.

http://en.wikipendia.org/wiki/Virus_Wikipedia, the free encyclopaedia, accessed on 01/04/2007.

http://www-micro.msb.le.ac.uk/109/structure.html-University of Leicester online notes. Virus Structure. Accessed on 01/04/2007.

http://www.virology.net/Big_Virology/BVHomePage.html_-Big Book on Virus. Accessed on 01/04/2007.

http://en.wikipedia.org/wiki/Bacteriophages

http://en.wikipedia.org/wiki/Capsid

http://en.wikipedia.org/wiki/Porcine_Reproductive_and_Respiratory_Syndrome_Vir us

http://en.wikipedia.org/wiki/Virus_classification.

The references cited above will provide you with an overview of the study of viruses. The literature contains general characteristics of viruses, their classification, cultivation, reproduction and economic importance among other topics. To assess your grasp of the concepts prepare your own **short summaries** on the following topics:

- The structure of Viruses
- Classification of viruses and criteria used for their classification
- Cultivation and different assays; plaque, counting, quantal, and hemagglutination
- Reproduction method in viruses
- The importance of viruses in the environment

Laboratory Practical

Title: Viral morphology and classification

In this exercise you will be required to observe different prepared slides on the morphology of viruses. Arrange a visit to a virology laboratory where you should examine some infected samples of plants or cultured cells. For more on the classification of viruses go to http://en.wikipedia.org/wiki/Virus_classification. This website explains the classification of the different viruses in detail.

Materials: Microscope, slides, variety of media, culture dishes, incubator, clean and sterile work bench, Pasteur pipettes of various sizes, sample slides, infected plant or cultured cells.

Procedure: You will examine prepared slides or live samples (infected plant or cultured cells)

Report: As outlined in Learning Activity # 1.

Study visits/Self Studies

Make a visit to a local farm (preferably of tobacco or cassava plantations) to identify virus infected crops. Record the symptoms observed and the conditions under which they flourish. Similar study visits should be arranged to a research station (agricultural or livestock) where a virology laboratory is in operation.

Objective: The objective(s) of study visits will vary according to the purpose, but mainly to examine symptoms caused by viruses on important cash crops and domesticated animals and to record their effects on the hosts.

Procedure: This will also depend on the objective of the visit itself. However, it will be important to liaise with a virologist at a research station who will arrange activities for demonstration relating to some of the exercises the expert would be working on at the time of making the request.

Report: You will be required to write a report based on your observations or activities recorded during the visit. Whenever applicable, specific methods employed should also be described in sufficient detail.

Assignment:

As explained in Learning Activity # 1.

Examples of Assignments:

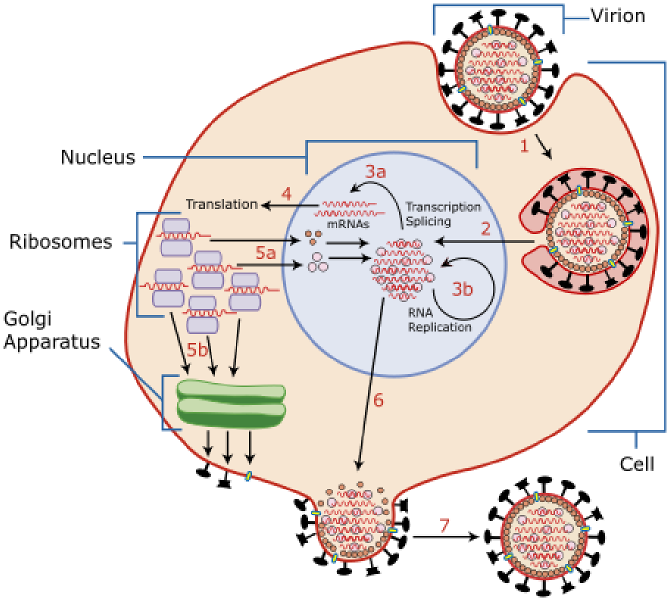
1. **Question:** With the aid of well-labeled diagrams, describe the structure of a virus.
   Answer frame work: Your response ought to include the following:
   - Size, nucleic acid composition
   - Shapes (isometric, helical or complex, and the sheath/tail if present.
   - Package of proteins in the nucleocapsid and the attachment devices.
   - Compare and contrast the naked and the enveloped viruses.

2. **Question:** Describe the classification of viruses.
   Answer frame work: Here you are supposed to indicate the followings:
   - Criteria used for the classification of viruses.
   - The suffix of major families.
   - Major groups of RNA and DNA animal infecting viruses.
   - Non-taxonomic groupings based on the route of transmission, organisms infected and diseases caused.

3. **Question:** Explain the establishment of a primary cell line for the culture of viruses.
   Answer frame work: You may need to say the following:
   - Define a primary cell line.
   - Materials needed to establish a cell line in terms of; source, chemicals/ reagents, equipments and conditions.
   - Outline procedures followed for maintenance of such cell lines.

4. **Question:** For pathogenic viruses, there are a number of critical stages in replication which determine the nature of the disease they produce. Describe what happens in each of these stages.
   Answer frame work: The first thing is to know the stages, and then describe each one of them. The stages involved are;
   - entrance
   - primary replication
   - dissemination stage

- cell or tisssue tropism
- host immune responses (Secondary replication direct cell/tissue damage) and
- persistence against clearance of the virus by the host.



Virus Replication

A virus attaches to the host cell and enters by endocytosis. The capsid protein dissociates and the viral RNA is transported to the nucleus. In the nucleus, the viral polymerase complexes transcribe and replicate the RNA. Viral mRNAs migrate to cytoplasm where they are translated into protein. Then the newly synthesized virions bud from infected cell.

http://en.wikipedia.org/wiki/Virus
accessed on 9/4/2008

Formative evaluation

Test yourself by attempting the following questions.

1. **Write short notes on:**
   (a) Antigen.
   (b) Capsid.
   (c) Lysis.
   (d) Attenuate.
   (e) Bacteriophages
2. **Compare and contrast between:**
   (a) Positive-strand RNA and negative-strand RNA.
   (b) Productive and abortive infections.
   (c) Virioids and prions.
   (d) Lantent and chronic infections in terms of the virion?
3. **For a virus to multiply, it must obviously infect a cell. Discuss this statement.**
4. **Outline the stages of viral replication.**
5. **Describe the methods applied in sterilization and disinfection of viruses.**
6. **Describe the most important taxonomic criteria used in viral classification?**
7. **Explain the attributes of a good vaccine.**
8. **Write short answers to each of the following:**
   (a) Name at least four viruses under the DNA and RNA types, indicating the diseases they cause in each case.
   (b) state the functions of interferons.
   (c) Discuss the classification of viral infections using the results of the immune response?
9. **Discuss the agricultural importance of viruses.**

The following site provides valuable information regarding possible video material which could be accessed to help answer some of the questions. http://www.microbiologybytes.com/video/index.html (Retrieved on 02/04/2007).

Microbiology Laboratory
Fungi, Bacteria, BioBurden, USP ASTM, Sterility, Validations, PCR
www.EMSL.com

Powerpoint To Video
Web-ready Flash from your live PowerPoint presentations & webcam.
www.CamtasiaStudio.com

Biology Experiments
Simplify your labs & empower your students with dynamic experiments
www.biopac.com

Ads by Goooooogle

Advertise on this site

Introduction to Microbiology | Infection & Immunity | Virology | Maths for Biologists

Home | Search
Microbiology Blog
Microbiology Podcasts
Microbiology Video Library
LabWork:
Online Experiments
Online Tutorials

"Particularly impressive are the wide variety of easily downloaded high quality images and short QuickTime movies. These may be particularly useful for staff to use for PowerPoint lectures and for student presentations: ... a useful source of information for both staff and students"
Microbiology Today, August 2002

The Microbiology Video Library now has videos on over 300 topics

You can now buy the Microbiology Video Library on CD: no download problems, delays or phone bills, & the videos on the CD are bigger, better and longer: include movies in your Powerpoint presentations!

Frequently Asked Questions about these videos

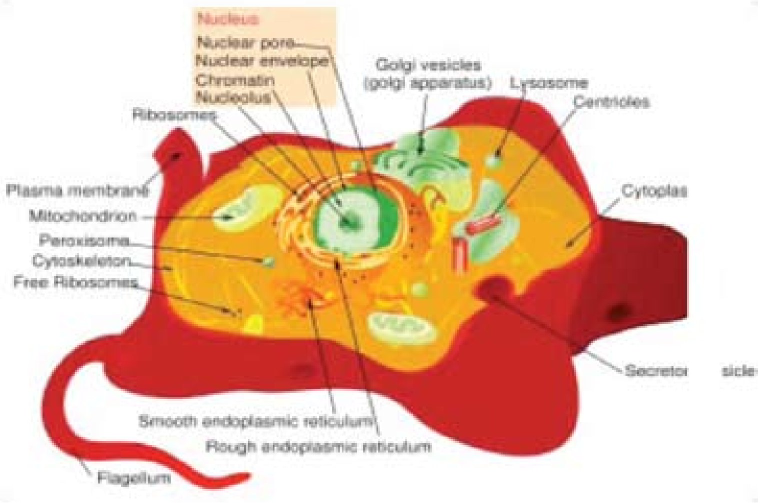
- The Origin of BSE
  When BSE emerged in British cattle in the mid-1980s, the theory was that cows had contracted the disease by eating feed conta...
- College Tips
  The Ninja gives some helpful tips about surviving college.MicrobiologyBytes.com...
- Equine herpes virus USA
  Equine herpes virus (EHV-1) causes a serious disease of horses that can cause abortion and death. In 2006, a group of 15 hors...

Learning Activity # 3

Title of Learning Activity : **The Protozoa**

Summary of the Learning Activity

This learning activity is going to cover another group of microorganisms known as Protozoa. In this activity, you are going to classify protozoa and learn about their biology, which will include nutrition, respiration, growth and reproduction, excretion and their economic importance. Protozoa are unicellular organisms, which are usually found in the mud at the bottom of ponds and ditches. The contents of a protozoan cell are enclosed by a thin limiting membrane. They have a simple structure comprising of a clear outer layer called the ectoplasm and an inner more granular endoplasm. The endoplasm contains organelles similar to those found in higher animals such as a true nucleus, mitochondria, golgi apparatus, endoplasmic reticulum, ribosomes and vacuoles. They include both free-living and parasitic forms. The parasitic protozoa inhabit both plant and animal hosts at all phylogenetic levels, and the intracellular parasites can be found in almost all cell types. The parasitic protozoans are microparasites because of their small size. They divide within their definitive host cells and generally cause acute, rather than chronic, diseases.



Structure of a generalized eukaryotic cell

http://en.wikipedia.org/wiki/Eukaryotes
Accessed on 18/04/2007

Key concepts

Protozoology: A branch of biology, which deals with the study of protozoa.

Pseudopodia: Is a complex infrastructure of microtubules, microfilaments and other organelles associated with the cell membrane in flagellated and ciliated protozoa.

Hyperparasitism (polyparasitism): A situation in which one organism which is a parasite to another, is parasitized by yet another parasite of its own (i.e., a parasite being parasitized).

Merogony (schizogony): Is a type of asexual reproduction in the phylum Apicomplexa in which after nuclear division, the individual nuclei move to the cells periphery and when nuclear division is completed, the cytoplasmic membrane then surrounds each nucleus and the daughter cells bud from the parent.

Bradizoite: A stage in the life cycle of protozoa of the family Sarcocystidae (tissue-cyst-forming coccidia). In particular this is the term used to describe the merozoite which forms within the tissue cyst in the intermediate host (and rarely within the definitive host). This infectious stage rarely infects new cells within the intermediate host; rather it is the infectious stage for the definitive host.

Gametocyte: The stage in the life cycle of some protozoa (Apicomplexa) which is destined to become a gamete (macro-or micro-).

Trophozoite: A stage of development in protozoa in which the organism is said to be mature, vegetative or in the active feeding form.

List of relevant readings

http://en.wikipedia.org/wiki/Protozoa

http://en.wikipedia.org/wiki/Flagellate

http://en.wikipedia.org/wiki/Amoeboid

http://en.wikipedia.org/wiki/Sporozoans

http://en.wikipedia.org/wiki/Malaria#Distribution_and_impact

http://en.wikipedia.org/wiki/Cryptosporidiosis

http://en.wikipedia.org/wiki/Coccidia

http://en.wikipedia.org/wiki/Cryptosporidiosis

http://en.wikipedia.org/wiki/Toxoplasmosis

http://www.tulane.edu/~wiser/protozoology/notes/intes.html Intestinal Protozoa, accessed on 19/04/2007.

Frobisher, M., Hinsdill, R.D., Crabtree, K.T. and Goodheart, C.R.1974. Fundamentals of Microbiology. Sounders College Publishing, West Washington Square, Philadelphia, PA 19105.

Nester, E.W. Anderson, D.G., Roberts (Jr.), C.E., Pearsall, N.N., and Nester, M.T. 2001. Microbiology: A Human Perspective. McGraw-Hill Companies, Inc.

List of optional readings

Blake, L. *et al.* 2002. Biology 12. McGraw-Hill Ryerson Ltd.

Mader, S.S. 2004. Biology. McGraw-Hill Companies, Inc., 1221 Avenue of the Americas, NY 10020.

List of relevant useful link

http://www.who.int/mediacentre/factsheets/fs094/en/

Detailed description of the learning activity

In this activity you will learn that protozoa which belong to the Kingdom Protista constitute a group of eukaryotic cells. They have a membrane-bound nucleus as well as the other membrane-bound organelles that are characteristic of higher animals. Protozoa are organisms that traditionally have been considered part of the microbial world. The protozoa are microscopic, unicellular organisms that lack photosynthetic capability, usually are motile at least at some stage in their life cycle, and reproduce most often by asexual fission. Protozoa have specialized structures for movement such as cilia, flagella, or pseudopodia. Since they live in aquatic environments, water, oxygen, and other small molecules readily diffuse into the cell through the cell membrane. In addition protozoa take in food either by pinocytosis (ingestion of fluid into a cell forming an internal vesicle) or phagocytosis (engulfing solid food particles and forming a food vacuole) as a means of obtaining water and food. Classification of protozoa shows that they are not a unified group, but appear along the evolutionary continuum; and the reason that they are lumped together in the group known as **protozoa** is because they are all single-celled eukaryotic organisms that lack chlorophyll. Protozoa are divided into three phyla and these are; **Sarcomastigophora**, **Ciliophora** and **Apicomplexa**. The phylum Sarcomastigophora is divided into two Sub-phyla, which are **Sarcodina** or amoeboid protozoa such as *Entamoeba histolytica,* and **Mastigophora** or Kinetoplasta the flagellated protozoa such as *Trypanosoma brucei*. Ciliophora are the ciliated protozoa such as *Balantidium coli* and Apicomplexa are protozoa that form spores such as *plasmodium falciparum.*

All these parasites are intracellular because they penetrate the host cell except Ciliophora which live in the lumen of the large intestine. A majority of protozoa are free-living and found in marine, freshwater, or terrestrial environments. On land, protozoa are abundant in muddy soils at the bottom of ponds and ditches as well as in or on plants and animals. Specialized protozoan habitats include the guts of termites, roaches, ruminants and humans. There are many diseases that protozoa cause other than those considered important by the World Health Organisation (WHO) such as malaria, sleeping sickness, Chagas disease and leishmaniasis. These Protozoa are an important part of the food chain (e.g. they eat bacteria and algae and, in turn, serve as food for larger species). Protozoa help to maintain an ecological balance in the soil by feeding on vast numbers of bacteria and algae (a single paramecium can ingest as many as 5 million bacteria in a day).

Other protozoa are important in sewage disposal because most of the nutrients they consume are metabolized to carbon dioxide and water, which results in a large decrease in total sewage solids. Some species however are parasitic, living on or in other host organisms. The hosts for protozoan parasites range from single-celled organisms, such as algae, to complex vertebrates, including humans. All protozoa require large amounts of moisture for survival, regardless of their habitat. Using amoeba as an example, the respiratory activity is mainly by the absorption of oxygen from the surrounding water through the whole surface of the ectoplasm. It is from there that oxygen diffuses to all parts of the cell. Amoeba lives on microorganisms such as diatoms or fragments of decayed organic matter. The food is contained in what are called food vacuoles within the endoplasm. Amoebae assimilate the food into their protoplasm for growth. When a maximum growth stage is reached, the cell nucleus divides into two followed by cytoplasmic cleavage in a process called binary fission. Two identical daughter cells arise from the asexual mode of reproduction. However, sexual reproduction is also possible among the protozoa but this is achieved through a process called conjugation. If the growing conditions become unfavourable the cells round off and release a protective covering called a cyst. Excretion is achieved through a contractile vacuole which grows slowly as it accumulates waste materials until it discharges its contents to the outside through the ectoplasm. Another example of protozoa is the unicellular organism called paramecium.

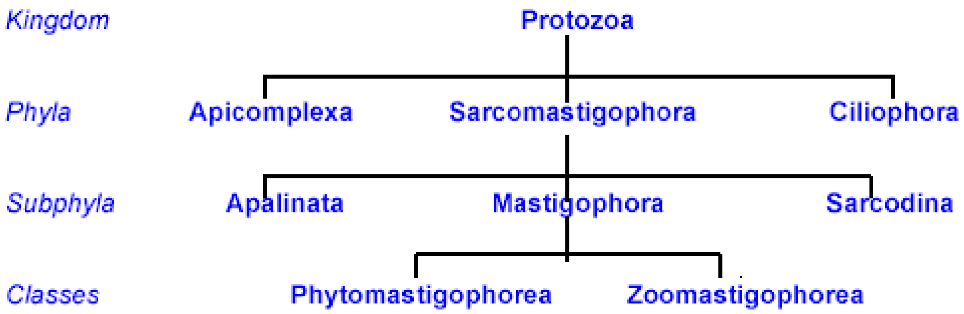


Figure of Abbreviated classification of the parasitic Protozoa

Learning Activities

Readings: Read the following books and links on6. Curd, C.R. 1992. Protozoa and the water industry. Cambridge University Press, MA.

Protozoa:

http://en.wikipedia.org/wiki/Protozoa

http://en.wikipedia.org/wiki/Flagellate

http://en.wikipedia.org/wiki/Amoeboid

http://en.wikipedia.org/wiki/Sporozoans

http://en.wikipedia.org/wiki/Coccidia

http://www.tulane.edu/~wiser/protozoology/notes/intes.html

Cox, F. E. G. 2001. Modern parasitology, Blackwell Science

Curd, C.R. 1992. Protozoa and the water industry. Cambridge University Press, MA.

These readings will provide you with an overview of the morphology, classification, reproduction, ecology and economic importance of protozoa. From these readings, prepare your own brief summaries on the following:

1. Classification of protozoa (note the distinguishing characteristics of the major phyla: Sarcomastigophora, Ciliophora, Apicomplexa and Microspora).
2. Ecology of protozoa. (Discuss the parasitic and nonparasitic forms using specific examples to show how the environment supports their livelihood)
3. Growth and reproduction (types and life cycles, of both disease and non disease causing protozoa).
4. Respiration (concentrate on how the organisms acquire their oxygen from the environment to generate energy)
5. Nutrition (take note of the mode of feeding and types of food source)

6. Excretion (note how the cells expel their waste to the environment)
7. Economic importance (especially in medicine, ecosystems and waste treatment).

Laboratory Practical

Title: Diversity and morphology of protozoa

In this exercise you will be required to examine different samples (water, blood, stool, etc.) for the diversity of protozoa and to learn about their morphology and life cycles.

Materials: Microscope, samples, Petri dishes, and sample slides, saline solution.

Procedure: To detect the presence of protozoa from humans and domesticated animals you should collect stool and blood samples using recommended procedures. You will examine different slides or real samples containing the protozoa. Make observations and compare notes with what you read from various sources.

For practical microscopy, you may visit the following website: http://www.micro.magnet.fsu.edu/primer/virtual/virtual.html where you will be given the opportunity to do a virtual exercise. The site explains that: “This interactive Java tutorial explores the effect of increasing magnification (equivalent to changing microscope objectives) on the ability to resolve features in a sample. We provide actual size images of the sample so that students can understand the dramatic increases in magnification of the samples they are examining. Each magnification is accompanied by a description of the features available at that resolution. Samples featured in this module include computer chips, Moon rocks, superconductors, and the surface of a Compact Disc”.

Report: As outlined in the Learning Activity # 1.

Study visits/Self Studies

Make a visit to a research station (agricultural or livestock), or to a sewage treatment station if possible.

Objective: The objective(s) of such a study visit will vary according to the purpose.

Procedure: This will also depend on the objective of the visit itself.

Report: You will be required to write a report based on your records from observations made during the study visit. Whenever applicable, specific methods employed should also be described.

Assignment

As explained in the Learning Activity # 1.

Examples of Assignments:

1. **Question:** Discuss the ecology of protozoa and explain their ecological significance.

Answer framework: Your response may include the following facts:

- Protozoa act as producers in both freshwater and saltwater ecosystems. - They are part of *plankton* (Gr. *plankt*, wandering), organisms that are suspended in the water and serve as food for heterotrophic organisms.
- They enter symbiotic relationships ranging from parasitism to mutualism (coral reef formation is greatly aided by the presence of a symbiotic photosynthetic protists that live in the tissues of coral animals).
- Polluted waters often have a rich and characteristic protozoa fauna. The relative abundance and diversity of protozoa can be used as indicators of organic and toxic pollution (i.e. used as environmental quality indicators).
- Symbiont protozoa such as ciliates that inhabit the rumen and reticulum of ruminants and the caecum and colon of equids are believed to aid the animal in digesting cellulose.
- Protozoa are employed as tools of study for various research projects; because of their small size, short generation time and ease of maintaining them in the lab.

2. **Question:** Malaria is one of the most important protozoa diseases. Malaria in man is caused by a protozoan parasite of the genus *Plasmodium*. For an effective control strategy, it is important to understand its life cycle. Describe the life cycle of *Plasmodium* spp.

Answer framework: See the following hints:

A] The life cycle involves two stages of development: one, *asexual*, passed in the human body; the other, *sexual*, passed on to the female of various species of mosquitoes of the genus *Anopheles*.

B] Cycle in man -*Plasmodium* parasites are introduced in mosquito's saliva when it bites.

- The parasites undergo a short period of multiplication in certain cells/tissues in the body, especially the liver cells (this is called **exoerythrocytic** or **preerythrocytic** cycle).
- The asexual progeny enter red-blood cells and grow within them (**trophozoite** stage).
- The parasite mutiplies asexually within the red blood cells, forming a number of small bodies or segments.

- Formed segments then escape to the blood; each segment as a new active parasite is called **merozoite**.
- Merozoites attack other erythrocytes and the multiplication process is repeated (the host experiences the chills and fevers characteristic of malaria).
- After passing through several cycles of asexual development, dinstinctive **gametocytes** begin to appear in the blood of the patient (they are larger than the asexual forms).
- gametocytes do not undergo further development in human erythrocytes, and they actually die if not taken by a mosquito.

C] Cycle in the mosquito

- when an *Anopheles* mosquito bites a person who has mature malarial gametocytes in her/his blood, the sexual stage of the parasite begins.
- after fertilization of the female by the male gametocyte in the stomach of the mosquito, the motile **zygotes** invade the cells lining the mosquito's stomach and multiply there, forming a sac (**oocyst**) wherein the parasite undergoes further development by fission.
- The sac ruptures, liberating numerous new young parasites which after moving about for some days (about 12), they will reach mosquito's salivary glands and from there are injected into man when the insect bites.

3. **Question:** Characterize the classification of protozoa, indicating the disease-causing genera of each phylum or subphylum.

   Answer frame work: Hints:

- indicate the criteria used to classify protozoa.
- major phyla and suphyla:
- Phylum: Sarcomastigophora – includes two subphyla in which most of the human disease-Disease causing protozoa are found;
- Sub-Phylum: Mastigophora – includes the flagellated protozoa; mostly unicellular and have one or more flagella at some time in their life cycle. The flagella are used for locomotion and food gathering as well as sensory receptors. The most important disease-causing Mastigophora are; *Giardia lamblia*, *Leishmani* spp, *Trichomonas vaginalis*, *Trypanosoma brucei rhodesience* and *Trypanosoma brucei gambience*.
- Sub-Phylum: Sarcodina – move by means of pseudopodia; and thus change shape as they move. e.g. *Entamoeba histolytica*.
- Ciliophora or the ciliates, includes organisms that have cilia.Most of them are free or symbiotically-living organisms such as
  Balantidium coli.

- Phylum: Apicomplexa cause some of the most serious protozoan diseases of humans. Malaria is caused by one of four *Plasmodium* species, and it is transmitted by the female *Anopheles* mosquito. Cats are the primary hosts for *Toxoplasma gondii*, with humans serving as secondary hosts. Another example of Apicomplexa is *Cryptosporidium parvum*, which causes diarrheal disease known as cryptosporidiosis.
- Phylum: Microspora includes the intracellular protozoa that infect immunocompromised humans, especially persons with AIDS.

Formative evaluation

1. Describe the key features of protozoa.
2. Compare and contrast the various modes of locomotion in protozoa.
3. Give the meaning of the following terms:
    - Commensal
    - Heterotroph
    - Cytoskeleton
    - Pseudopodium.
    - Merozoite.
    - Schizogony.
4. Differentiate between sporozoites and merozoites.
5. What are the environmental conditions required for survival of protozoa?
6. Outline the pathophysiology of trichomoniasis.
7. Describe in detail the *Plasmodium* life cycle in humans.
8. Outline the classification of clinically significant protozoa, giving the genus and species names and the diseases they cause.
9. Although protozoa are frequently overlooked, they play an important ecological role in the environments of many communities. Discuss.
10. State a disease caused by each of the following protozoan and indicate how they are transmitted to humans:
    - *Entamoeba histolytica.*
    - *Acanthamoeba.*
    - *Giardia lamblia.*
    - *Trichomonas vaginalis.*
    - *Trypanosoma brucei gambiens.*
    - *Balantidium coli.*
    - *Cryptosporidium.*
    - *Plasmodium* species.
    - *Toxoplasma gondii.*

Learning Activity # 4

Title of Learning Activity: **Mycology**

Summary of the Learning Activity

This learning activity is going to cover the general characteristics of fungi, mycelial structure and organization, types of nutrition, reproduction, ecology, classification and their economic importance. Fungi were initially classified as plants, and the study of fungi called mycology developed as a branch of botany. However, fungi are now considered to have unique characteristics to justify placing them in a separate Kingdom of their own called Myceteae. Over 60 000 species of fungi are known. The fossil record suggests that fungi were present 550 million years ago and may have evolved even earlier. They range from tiny, single celled organisms invisible to the naked eye such as the yeasts to those that have visible fruiting structures such as the mushrooms. Fungi are classified primarily by the type of spores and fruiting bodies they produce, although molecular biology is beginning to take center stage in their taxonomy. Many mycologists divide the Kingdom Myceteae (the Fungi) into five main phyla; the Chytridiomycota, Zygomycota (zygospore fungi), Ascomycota (sac fungi) and the Basidiomycota (club fungi). The fifth phylum called Deuteromycota (imperfect fungi) is used by some taxonomists for fungi that apparently reproduce only by asexual spores.

Fungi are a member of a diverse group of eukaryotic organisms that unlike plants and animals obtain food by absorbing nutrients from an external source. The majority of fungi grow on and absorb food from substrates such as soil, wood, decaying organic matter as heterotrophic feeders, while others are obligate parasites subsisting on nutrients derived from living plant and animal tissues. Fungi are multinucleate, meaning that one cell can contain two or more nuclei. They obtain their energy from respiration in a similar way that higher plants and animals do. The outer layer of a fungal cell is a cell wall made of chitin substance, followed by a cell membrane below which is a cytoplasm, which contains all the organelles that are found in an animal cell. Unicellular fungi grow by binary fission whereas the multicellular ones do so by extension growth of the apical hypha. Fungal hyphae are collectively termed mycelium. Mycelia release their secondary metabolites to the environment through the cell membrane. Fungi are so diverse in their mode of reproduction to the extent that some reproduce exclusively by asexual means while others combine the asexual and sexual modes of reproduction. And yet others employ hormones in their sexual reproduction.

Fungi are both beneficial and a bother. From an ecological stand point, they are important as decomposers and recyclers of nutrients in an ecosystem. Economically, fungi are a source of food as many mushrooms are. They are also used in giving cheese their different flavours. Fungi are also industrially important in baking, brewing and in medicine as a source of antibiotics. In recent years fungi have become a focus of intense study because of their use in biotechnological applications in processes related to industry, agriculture ad ecology. Fungi are a concern because they damage millions of dollars worth of farm produce through crop and animal diseases. Fungal infections in humans are among the most chronic of illnesses.

Fungi help to break down dead organic material (in this case a dead tree trunk) and help to continue the cycle of nutrients through an ecosystem.
http://www.ucmp.berkeley.edu/fungi/fungi.html
Accessed on 02/04/2007

Key concepts

Mycology: The study of fungi, and a person who studies fungi is known as a *mycologist*.

Hypha: A hypha (plural *hyphae*) is a long, filamentous cell of a fungus, constituting the main mode of vegetative growth. A hypha consists of one or more cells surrounded by a tubular cell wall. In most fungi, hphae are divided into compartments by internal cross-walls

Septa: These are dividing cross walls along the length of a hypha. They usually leave an opening at the centre called a septal pore. It is for this reason hyphae are said to have compartments and not cells because no single compartment has protoplasm exclusively to itself. The singular form of septa is s*eptum.*

Mycelium: A collection of hyphae of one fungus growing in one place is known as a *mycelium.*

Gametangia: The organ of a fungus where gametes are produced. The singular of gametangia is *gametangium*. A gametangium is a haploid structure and formation of gametes does not involve meiosis

Monoecious fungi: Fungal species which produce male and female sex organs in the same thallus (thus, *hermaphrodite*).

Thallus: This is body of an organism that is not differentiated into roots, stem and leaves.

Dioecious: Fungi that produce male and female sex organs on separate thalli.

Heterokaryosis: Heterokaryosis (from the Greek *heteros*, meaning *other* and *karyon*, meaning *kernel*) means to have two or more genetically different nuclei within the same mycelium of a fungus. The nuclei within the same mycelium may differ from one another either through the accumulation of mutations or through the fusion of genetically distinct hyphae. This can lead to individuals that have different nuclei in different parts of their mycelium.

Dikaryotic hypha: A hypha that contains paired haploid nuclei.

Spore: A spore is a reproductive cell that develops into a new organism without the need to fuse with another reproductive cell. Spores that are not contained in a capsule are referred to as **conidia**.

Sporangium: This is a capsule that produces spores called sporangiospores.

Asci: This is a capsule that produces a special type of spore called ascospores

Basidia: This is a capsule that produces a kind of spore called basidiospores

List of relevant readings

Alexopoulos, C. J. and C. W. Mims. 1996. *Introductory Mycology*, 4th Ed.b) J.W.

Deacon, J. W. 2005. Fungal Biology (4th ed). Malden, MA: Blackwell Publishers.

Hawksworth, D.L. (1974): Mycologist's Handbook. Kew: U.K., CAB International.

http://en.wikipedia.org/wiki/Fungus 02/04/2007

http://en.wikipedia.org/wiki/Ascomycota 02/04/2007

http://www.kcom.edu/faculty/chamberlain/Website/Lects/Fungi.htm Lecturer notes on Fungi. Accessed on 02/04/2007

http://pathmicro.med.sc.edu/mycology/myucology-1.htm. A book of Mycology. Accessed on 02/04/2007

List of optional readings

Blake, L. *et al.,* (2002): Biology 12. McGraw-Hill Ryerson Ltd.

Mader, S.S. 2004 Biology. McGraw-Hill Companies, Inc., 1221 Avenue of the Americas, NY 10020.

List of relevant useful links

http://mycology.cornell.edu/fteach.html

http://pathmicro.med.sc.edu/mycology/mycology-1.htm
A book of Mycology.
Accessed on 02/04/2007

Detailed description of the learning activity

Classification

The term mycology is derived from a Greek word *myke* which means 'mushroom', and *logos* which means 'study'. Therefore, mycology means literary the study of mushrooms. However, the term is commonly used to refer to the study of a group of organisms called **fungi**, whose singular is **fungus**. Fungi were believed to be monophyletic and to be derived from an algal ancestor that lost its ability to photosynthesise. However, over time, with the discovery of molecular techniques in determining relationships between organisms it was discovered that the fungi are made up of a polyphyletic group of organisms that, in some cases, are very distantly related to one another. Therefore, fungi are not grouped together because they are closely related, but rather because they share a combination of characteristics as outlined below. Whittaker (1969) proposed a five Kingdom system which to date is the accepted system of classification of organisms. It puts the fungi in a separate Kingdom of their own called the fifth Kingdom. The Kingdom Myceteae (Fungi) is divided into the Myxomycota, the slime molds and the Eumycota, the true fungi.

The more recent classification system based in part on molecular research is summarised below.

Phylum

Chytridiomycota: The Chytridiomycetes are represented by a group of primitive aquatic fungi, which comprise approximately 800 species. They produce motile gametes assisted by flagella. Their cell wall composition is mostly chitin. This group was placed in the Eumycota after molecular work with rDNA. The phylum Chytridiomycota has one class the Chytridiomycetes with the orders; Chytridiales and Blastocladiales. **Phylum** Zygomycota: The Zygomycetes are characterised by the formation of sexual spores called zygospores. They are a result of fertilisation between two haploid nuclei to form a diploid zygote. The zygote immediately undergoes meiosis forming haploid cells called zygospores. The outer coats of these cells are variously sculptured and are held between the tips of the mother hyphae. Two classes are recognised in this phylum and these are; Trichomycetes and Zygomycetes. The species of a Zygomycete can be determined from the type of zygospore produced. An example of a Zygomycete is the bread mold, *Rhizopus nigricans*. **Phylum** Ascomycota: The Ascomycetes are also called the 'sac fungi' because their sexual spores, the ascospores, are enclosed in a tube-like sac called an asci. The formation of ascospores is similar to that of zygospores, except that the ascospores formed by meiosis are enclosed in the asci. *Neurospora crassa* is an ascomycete mold that is used extensively in studies of genetics. The class Ascomycetes includes the unicellular orders Saccharomycetales and Schizosaccharomycetales, the yeasts. The filamentous Ascomycetes include the orders Eurotiales whose fruiting bodies are cleistothecia, the Sordariales and Xylariales whose fruiting bodies are perithecia, Pezizales whose fruiting bodies are apothecia and the Dothideales whose fruiting bodies are ascostroma. **Phylum** Basidiomycota: The Basidiomycetes are called the 'club fungi'. Their sexual spores, the basidiospores, are formed on fruiting structures called basidia. The Basidiomycetes include some of the fungi whose aggregation of the hyphae result in the development of fruiting structures that are visible to the naked eye. Such fungi are called mushrooms and fall under the order Agaricales. The group includes the classes Teliomycetes, which comprise the rusts and the Ustomycetes, which embrace the smuts. **Phylum** Deuteromycota: This group of fungi is also called the 'imperfect fungi'. This is a group of fungi whose sexual stage has not yet been discovered. As the sexual stage of a fungus is discovered the fungus is removed from this group and gets its position in the Ascomycota. The orders of this group are; Moniliales whose conidia arise on conidiophores that are produced on mycelium (*Alternaria tenuis*), Sphaeropsidales whose conidia are borne on conidiophores are produced in pycnidia (*Phomopsis* sp.), Melanconiales whose conidia borne on conidiophores are produced in acervuli (*Pestalotia* sp.), Sterlia which produce sterile mycelium and therefore no conidia are produced, but other mycelial structures must be used for their propagation such as scelerotia (*Sclerotium* sp.)

Phylum

Lichens and Mycorrhizae: These are examples of beneficial associations between two different organisms. In Lichens there is an association between an alga (autotroph) with a fungus (heterotroph). The alga provides the fungus with a carbon source while the fungus provides the alga with nutrients from the substratum. The same applies to the association of fungi with plant roots when they form mycorrhizae. The fungus provides the root system of a plant with mineral nutrients while the fungus gets the carbon source from the plant in return. These are mutualistic associations.

Structure

Two structural forms exist among the fungi. One kind is unicellular as represented by the yeast cells. The other form is made up of thread like structures. Individual threads are known as **hyphae** whose singular form is **hypha.** Collectively hyphae are known as mycelium whose plural form is **mycelia**. The mycelium is the vegetative phase of a fungus, which subsequently gives rise to the reproductive structures. Whether it is a yeast cell or a filamentous fungus consisting of hyphae, fungi are typically made up of a porous outer cell wall made up of chitin, unlike the cell wall of plants that is made up of cellulose. Inner to the cell wall is a cell membrane that is convoluted in places to increase its surface area for exchange of materials. These structures are called lomasomes. The cell membrane encloses the cytoplasm, which suspends the cellular organelles typical of a eukaryotic cell. These are; a membrane bound nucleus, golgi complex, endoplasmic reticula, ribosomes, and vesicles. Two types of hyphae are represented by different groups of fungi. The lower fungi typically lack cross walls called **septa** whose singular is **septum**. Such hyphae are said to be **non-septate** and therefore **coenocytic** because their nuclei are contained in one continuous slug of cytoplasm. The hyphae of higher fungi have septa, which divide the tubular filaments into compartments. However, the septa leave a pore at the centre through which protoplasm can flow. Each compartment of a hypha contains one to two nuclei. Vacuoles are characteristic of the older segments of a hypha.

Nutrition

Fungi are achlorophylous, meaning that they do not contain chlorophyll to be able to make their own food like plants do. Fungi depend on other organisms for their carbon source. Therefore, they are heterotrophic feeders. Heterotrophs can either be saprobes, symbionts or parasites. As **saprophytes** they obtain their carbon source from the by-products of other organisms or from tissue of dead organisms as organic matter. When they are **symbionts** fungi usually live in close association with another dissimilar organism in a mutual beneficial relationship. This kind of relationship is called a mutualistic symbiosis. Other fungi are **parasites** in character. These are fungi that derive their nutrition from the protoplasm of another organism called the host. Fungi have a common mode of nutrition, which involves the release of enzymes on to the substratum in the environment. The substrate is digested outside the cell and absorption of the products (monomer forms) take place through the porous cell wall and the selectively permeable membrane for eventual assimilation by the cells. Various types of enzymes are produced depending on the type of fungus and the complexity of the substrate. A single enzyme is required to digest for instance a disaccharide, whereas two enzymes will be required to split a molecule of starch to its monomer units and yet three different types of enzymes would be required to digest crystalline cellulose. This kind of digestion which takes place outside the cell is called **extracellular digestion**. In addition to a carbon source, fungi also need to take in mineral nutrients to supplement their metabolism, just like higher organisms need the supply of nitrogen, potassium, phosphorus, etc.

Respiration

Fungi breakdown their carbon sources to release energy for metabolism in the mitochondria like all eukaryotic cells do, through the following metabolic pathways; glycolysis, Krebs cycle and electron transport chain is the main pathway used to release energy for a cell.

Growth and development

The unicellular fungi grow by binary fission. The mycelial fungi grow by apical extension. The apical compartment has a very thin cell wall at the tip, which allows the apical compartment to extend in length due to internal cytoplasmic turgor pressure. After attaining a maximum volume, the apical compartment under goes nuclear and cytoplasmic division resulting into two compartments.

Reproduction

In fungi either sexual or asexual reproduction or both may occur by spore production, often produced on specialised structures called conidiophores, which in turn bear conidia or in sporangia, which contain sporangiospores, or variously shaped fruiting bodies such as asci, which carry ascospores, or acervuli on which another kind of conidia are borne. The kinds of reproduction methods are varied according to the type of fungus in reference. However, asexual reproduction is the major means by which fungi reproduce by either fragmentation of cells, binary fission or by budding. The other method of reproduction in fungi is parasexual. Refer to the life cycles of the representative fungi from the different taxonomic groups at the website given in the compulsory readings to appreciate the different kinds of reproductive methods found among the fungi.

Significance

Fungi are important in the food industry. Mushrooms which are the macroscopic fruiting structures of the Basidiomycota form a delicacy at the dining table in many countries. A variety of species including *Penicillium* sp. are used to add flavour to cheese. The cheese flavour would depend on the fungus species the cheese is inoculated with. The yeasts are important in the leavening of dough in baking and the fermentation processes of wine and beer manufacturing. In ecological systems, fungi are useful in the breakdown of organic matter and organic wastes and therefore contribute significantly to the recycling of nutrients and cleaning up of wastes in an ecosystem. They are also an important tool in research, because several generations of a fungus can be produced in a short time. The field of medicine has benefited immensely from the exploitation of fungi for their medicinal value. As mycorrhizal fungi they are known to have a mutualistic existence with plants, in which plants enhance their phosphorus uptake, while the fungus benefits from the carbon source provided by the host plant. On the other hand fungi are an agricultural inconvenience because they cause disease on plants and animals, which cost farmers billions worth of profits. A large number of fungi cause a variety of diseases in plants, but only a few species cause disease in animals and humans, and when they do they cause persistent illnesses.

Learning Activities

Readings: Read the following books and links on Mycology:

Alexopoulos, C. J. and C. W. Mims. 1996. *Introductory Mycology*, 4th Ed. Deacon, J.W. 2005. Fungal Biology (4th ed). Malden, MA: Blackwell Publihers.

Hawksworth, D.L. 1974. Mycologist's Handbook. Kew: U.K., CAB International. 8015iv.

http://en.wikipedia.org/wiki/Fungus

http://en.wikipedia.org/wiki/Ascomycota nilvi.

http://www.kcom.edu/faculty/chamberlain/Website/Lects/Fungi.htm Lecture notes on Fungi. Accessed on (02/04/2007).

http://pathmicro.med.sc.edu/mycology/mycology-1.htm A book of Mycology.

Accessed on 02/04/2007

The readings above provide you with information on the characteristics, structure nutrition, reproduction and economic importance of fungi. From these readings, prepare summarized notes using the following titles:

1. General characteristics of fungi
2. Mycelial structure, organization and growth
3. Types of nutrition in fungi (saprophytism, parasitism, symbiosis)
4. Methods of reproduction (asexual, sexual and parasexual)
5. Major divisions of fungi, their corresponding life cycles and spore types such as ascospores, basidiospores, zygospores,and oospores
6. Collection, culture, preservation and identification methods of fungi
7. Economic importance (Diseases in plants and animals; nutritive value (as food), in medicine (antibiotics), fermentation processes (brewing), baking, as decomposers, and research

Laboratory Practical

Title: Diversity and morphology of fungi.

In this exercise you will be required to examine different specimen samples from a wide range of representative groups of fungi.

Objectives:

At the end of the practical exercise the learner should be able to;

1. understand fungal diversity
2. understand the biology of fungi
3. compare fungal sub-groups in terms of body and reproductive structures.
4. understand the ecology of the fungi.

Materials: selected fungal cultures (plates/slants of specimens), microscope, slide and cover slip, specimens of *Saprolegnia* spp., *Rhizopu*s sp. or *Mucor* sp., *Candida* sp. *Agaricus* sp. and *Phoma* sp. Include specimens of lichens and mycorrhizae in the form of prepared slides.

Procedure:

- examine the fungal representatives for distinguishing characteristics. structures (e.g conidiophore, sporangium, pycnidia etc)
- examine the mushroom fungi and look for basidia and basidiospores
- examine slide preparations of lichens and mycorrhizae. Look for the physical association between the two dissimilar organisms living together

Report: The format outlined in the learning activity No. 1 above should be followed. Your report will now include representative drawings from the specimens observed and this can be included under the results section of the report.

Study visits/Self Studies

In order to achieve the objectives of this learning activity, you will need to organize group or individual study tours to different places where fungi are commonly known to grow, so that you can learn about their morphological characteristics, distinctive groups, and their ecological environments. For the biological applications, you will need to visit institutions and organizations that deal with mycological organisms. These may include; bakeries, brewing factories, cheese making plants, wine and bio-ethanol producing centres. Your report should include the names of fungi commonly used, the methods used to exploit the fungi, and how inoculum is preserved. For each technology, report on the process used to get the required results. Relate your experiences to the theoretical foundations explored during the literature review.

Objective:

At the ed of the study visit the learner should be able to;

- relate the theoretical knowledge to the practical experiences in the field.

Procedure: This will also depend on the objective of the visit

Report: You will be required to write a report based on your observations from the activities in the field. Whenever applicable, specific methods employed should also be described.

Assignment

As explained in the Learning Activity # 1.

Examples of Assignments:

1. **Question:** Discuss the economic importance of fungi.
   Answer frame work: Divide the response into the harmful and beneficial aspects of fungi:

Harmful aspects:

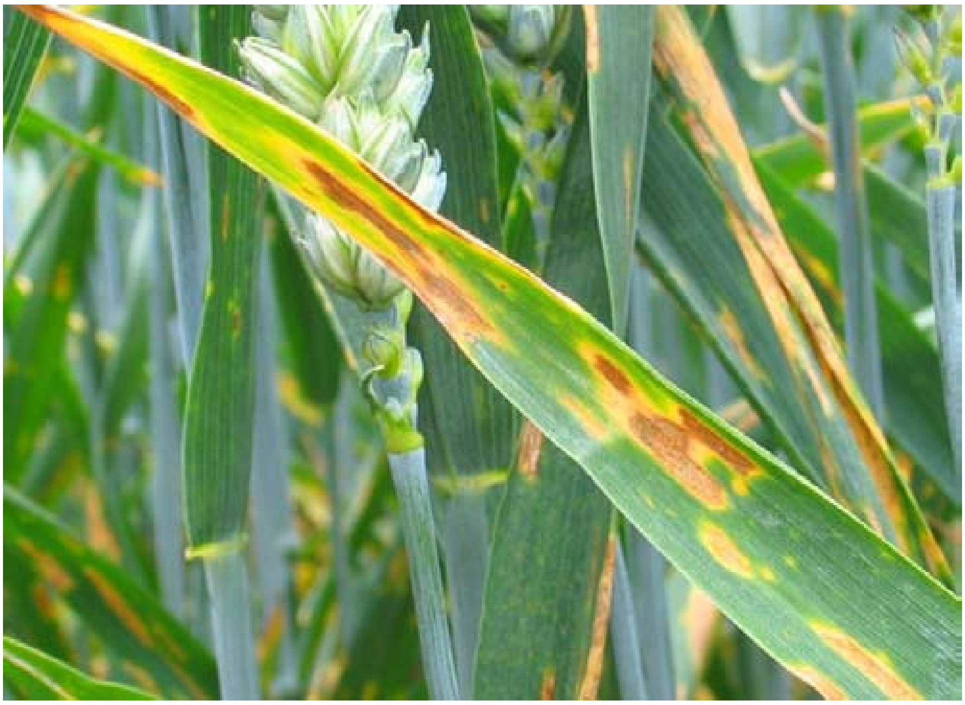
- Agents of disease
- *Candida albicans* is a yeast which attacks the mucous membranes causing infections of the mouth or vagina called thrush or candidiasis; and also blamed for 'yeast allergies'
- Dermatophytosis (tinea or ringworm) of the scalp, glabrous skin, and nails is caused by group of fungi known as dematophytes (e.g. *Trichophyton rubrum, T. interdigitale* and *Epidermophyton floccosum*).
- *Aspergillus flavus*, which grows on peanuts amongst other hosts, generates aflatoxin, which damage the liver and is highly carcinogenic.
- Dutch Elm Disease by *Ceratocystis ulmi* and transmitted by beetles
- Maize leaf curl, caused by *Cochliobolus heterophus*
- Wheat rust, caused by *Puccinia graminis* destroy tones of wheat yearly.
- *Uncinula necator* is responsible for the disease powdery mildew, which attacks grapevines.
- *Penicillium italicum* rots oranges.
- Some fungi like *Penicillium* and *Rhizopus* spp spoil stored food.
- Ergot (*Claviceps purpurea*) on rye is a direct menace to humans when it attacks wheat or rye and produces highly poisonous and carcinogenic alkaloids to humans if consumed.
- Fungi like *Epidermophyton* cause skin infections but are not very dangerous for people with healthy immune systems. However, if the immune system is damaged they can be life-threatening: For instance, *Pneumocystis jiroveci* is responsible for severe lung infections which occur in AIDS patients.

Beneficial effects of fungi

- Benefits
- Mushrooms are recognized and used as food in many parts of the world. Fermentation of sugars by yeast is the oldest and largest application of this technology. Many types of yeasts are used for making many foods: Baker's yeast in bread production, brewer's yeast in beer fermentation, yeast in wine fermentation, etc.

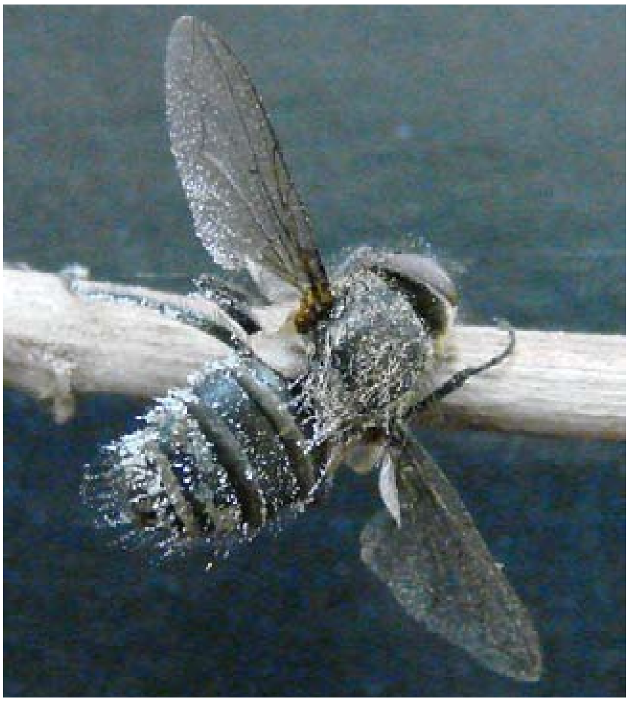
- The mold *Penicillium chrysogenum* (formerly *Penicillium notafum*), produces an antibiotic, which under the name Penicillin, triggered a revolution in the treatment of bacterial infectious diseases in the ^{t} Century.
- *Tolypocladium niveum* is an immunosuppressor which secretes ciclosporin, a drug administered during organ transplanting to prevent rejection; it is also prescribed for auto-immune diseases such as multiple sclerosis.
- Yeasts are the most widely used model organisms for genetic and cell biology (e.g. the mold *Neurospora crassa*). Some have been used to produce human insulin and the human growth hormone as well as vaccine against hepatitis B.
- Enzymes of *Penicillium camemberti* play a role in the manufacture of cheeses (e.g. Camembert and Brie) while those of *Penicillium roqueforti* do the same for Gorgonzola, Roquefort and stilton cheese types.

Examples of agents of diseases in plants and animals including humans:



(A) *Septoria tritici* is a fungus that causes these symptoms in a wheat plant

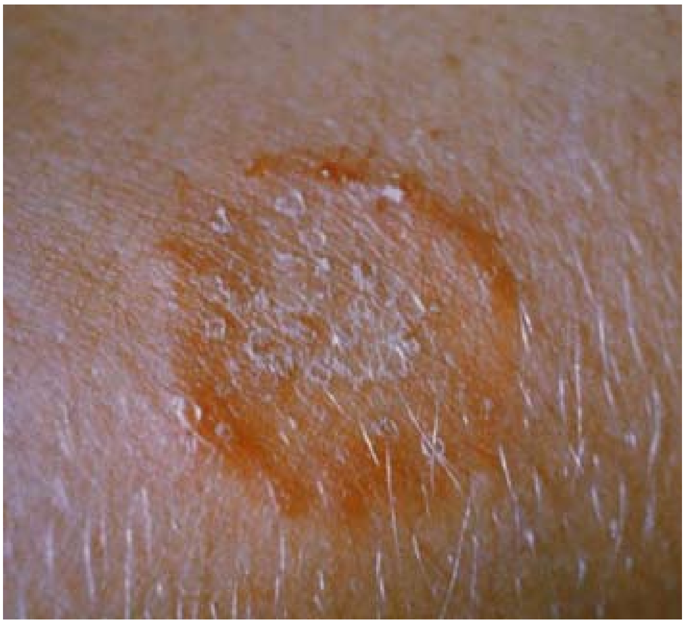
http://en.wikipedia.org/wiki/Image:Septoria-tritici.jpg
Accessed on 8/4/2008



(B) ***Entomophthora music*** is a fungus that grows in the body of an insect causing it to die

The **Entomophthorales** are an order of fungi that has traditionally been classified in the class Zygomycetes. Most species of the Entomophthorales are pathogens of insects. The name **Entomophthorales** is derived from the Greek for insect destroyer (Gk: entomo=insect, phthor=destroyer)

http://en.wikipedia.org/wiki/Entomophthorales
Accessed on 8/4/2008



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(C) **Ringworm**, also known as «Tinea» is an infection of the skin. Contrary to its name, ringworm is not caused by a worm but by parasitic fungi (Dermatophytosis). It can exist anywhere on the body.

http://en.wikipedia.org/wiki/Ringworm
Accessed on 8/4/2008

Examples of some beneficial effects of fungi

(A) Fermenting tanks with yeast used to brew beer
http://en.wikipedia.org/wiki/Image:Samadams2.jpg As of
Accessed on 19/04/2007

(

B) Baked food:
http://en.wikipedia.org/wiki/Image:Baked_food.jpg
Accessed on 8/4/2008

Microorganisms that release carbon dioxide as part of their lifecycle can be used to leaven products. Varieties of yeast are most often used, particularly *Saccharomyces* species or baker's yeast. Leavening with yeast is a process based on fermentation, physically changing the chemistry of the dough or batter as the yeast works. Yeast leaves behind waste byproducts (particularly ethanol and some autolysis products) that contribute to the distinctive flavor of yeast breads.

http://en.wikipedia.org/wiki/Leavening_agent#Biological_leaveners

2. **Question:** Outline the growth conditions required by fungi.
   Answer frame work: Consider the following tips in your answer;

- moist environments are preferred with a relative humidity in excess of 70%, a temperature range of -6°C to 50°C (optimum being 20-35°C). Some of them can inhabit hot springs environments
- pH conditions vary greatly, from as low as 2.2 to as high as 9.6 (optimum is 5.0 or lower).
- These conditions are necessary for optimum function of extracellular enzymes and absorption of the products of digestion.
- Most require oxygen and therefore they are aerobic in nature, but others like the yeasts are facultative (live under a range of extreme conditions) anaerobes not requiring oxygen and carry out alcoholic fermentation.

3. **Question:** What are the ways in which fungi cause disease in humans? **Answer frame work:** Fungi usually cause disease in humans in any one of the following ways depending on the organism in question;

- as an allergic reaction to inhaling fungal spores or vegetative cells causing diseases such as hay fever and asthma, which is a disease of the respiratory system caused by allergies with symptoms of coughing, sudden difficulty in breathing, and a tight feeling in the chest.
- as a reaction to the toxins produced by some species of fungi (some produce toxins that are carcinogenic, e.g. *Aspergillus* produce aflatoxins, ergot from *Claviceps purporea*, etc).
- growth of fungi on or in the human body causing diseases or mycoses called histoplasmosis, which is a severe disease of the lungs caused by the fungus *Histoplasma capsulatum*; coccidioidomycosis, a respiratory disease of humans and domestic animals caused by inhalation of spores from a fungus called *Coccidioides immitis*; and candidiasis which are infections caused by yeasts such as *Candida albicans*.
- Fungi cause disease to plants destroying tones of crop yields per year. A shortage of food in a household can lead to malnutrition.

4. **Question:** Discuss the different kinds of symbiotic relationships fungi form with other organisms. Explain how these relationships are beneficial to each partner. **Answer frame work:**

There are two types of such relationships:

Lichen symbiosis

- This is an association of fungi with photosynthetic organisms such as algae or a cyanobacterium.
- A fungus provides protection and a growth platform for the other organism.
- The fungus supplies absorbed water and minerals to the partner organism.
- The photosynthetic member supplies the fungus with organic nutrients as a carbon source.

Mycorrhizae

- These are close associations between fungi and the roots of certain plants sustained by mutual beneficial effects between them.
- Fungi increase the absorptive surface area of the root and an enhanced uptake of inorganic phosphate in phosphate poor soils, thereby allowing their plant partners to grow in soils where these plants could not otherwise survive.
- Fungi in turn obtain the synthesized organic nutrients from the plant partner.

Formative evaluation

1. Write short notes on each of the followings items as applied in mycology.
   (a) Chitin cell wall.
   (a) Reproduction by budding.
   (a) Parasexualism
   (a) Heterokaryosis.

2. Describe the general characteristics of the …
   (a) yeasts and
   (b) the filamentous fungi.

3. Compare and contrast the mode of nutrition between …
   (a) fungi and plants
   (b) fungi and animals

4. Describe the structure and function of each of the following parts of a fungus.
   (a) Hyphal tip.
   (b) Stolon.
   (c) Rhizoids.
   (d) Conidiophore.

5. Compare and contrast an ascocarp of the Ascomycota and the basidiocarp of a Basidiomycota.

6. Explain how the following asexual spores are produced.
   (a) Conidia
   (b) Sporangiospores
   (c) Pycnidiospores

7. Write short answers to each of the questions below.
   (a) Describe a lichen?
   (b) Discuss mycorrhizal associations?
   (c) Explain the peculiar nature of the 'imperfect fungi'
   (d) Discuss the role of fungi in an ecosystem.
   (e) Compare and contrast rhizomorph to a mycelial strand.

8. Outline the life cycle of *Rhizopus* sp.

9. Search the internet for pictures of various organisms that belong to the Kingdom Fungi. Provide a brief taxonomic description under each picture of a representative organism for each of the following groups of fungi.
    (a) Chytridiomycota
    (b) Zygomycota
    (c) Ascomycota
    (d) Basidiomycota
    (e) Deuteromycota

10. Discuss the facts that fungi are a blessing as well as a curse.

XI. Compiled List of all Key Concepts (Glossary)

SPORANGIUM: A capsule made up of intertwined fungal filaments that contain sporangiospores.

ASCI: This is a capsule that produces a special type of spore called ascospores

BASIDIA: This is a capsule that produces a kind of spore called basidiospores

THALLUS: This is body of an organism that is not differentiated into roots,

ASEPTIC TECHNIQUE: Refers to procedures used to prevent the

BACTERIOLOGY: A branch of microbiology which deals with the study

BACTERIOPHAGE: These are viruses that infect bacteria.

BRADIZOITE: A stage in the life cycle of protozoa of the family

CHEMOSTAT: A device used in a continuous culture of bacteria so as to maintain a bacterial population at a constant density; a situation that is, in many ways, more similar to bacterial growth in natural environment.

CONJUGATION: A kind of reproduction in single celled organisms in which one cell passes genetic material (DNA) to another through a conjugation tube called the sex pilus that temporarily joins the two conjugating cells. contamination of sterile cultures or media and spread of microorganisms into in an environment.

CYTOPATHIC EFFECT: Are characteristic changes of the cells' appearance observed in tissue culture cells when they are attacked by viruses.

DIKARYOTIC: A hypha that contains paired haploid nuclei.

DIOECIOUS : Fungal species which produce male and female sex organs in separate thalli.

ENDOSPORES: Highly resistant dormant structures formed by certain genera of Gram-positive bacteria such as Bacillus and Clostridium.

GAMETANGIA: A gametangium (plural gametangia) is an organ or cell that is found in some multicellular fungi in which gametes (for male = antheridium; and female = oogonium) are produced.

GAMETOCYTE: The stage in the life cycle of some protozoa (Apicomplexa) which is destined to become a gamete (macro-or micro-).

HETEROKARYOSIS: It is a term used in mycology meaning to have two or more genetically different nuclei within the same mycelium of a fungus.

HYPERPLASIA*:* Is excessive cell division or the growth of abnormally large cells,resulting in the production of swollen or distorted areas of the organism.

ofbacteria. Sarcocystidae (tissue-cyst-forming coccidia). stem and leaves.

HYPHA: A hypha (plural hyphae) is a long, filamentous cell of a fungus, constituting the main vegetative part of a fungus.

MEROGONY (SCHIZOGONY): Is a type of asexual reproduction in the phylum Apicomplexa in which a single cell undergoes several nuclear divisions before the cytoplasm divides around them to form individual parent cells. The malaria parasite reproduces rapidly in tissues of the host this way.

MICROSCOPY: Any technique for producing visible images of structures or details too small to be seen by the naked human eye.

MONOECIOUS: Fungal species which produce male and female sex organs in the same thallus and therefore assuming a **hermaphrodite** condition.

MYCELIUM: A collection of hyphae that form the vegetative body of a fungus that is capable of feeding and reproducing.

MYCOLOGY: A branch of biology that specializes in the study of fungi.

NUCLEOCAPSID: The viral capsid together with the nucleic acid that is tightly packed within the protein coat.

PLASMIDS: Small circular DNA contained in the cells of bacteria. They often contain genes for antibiotic resistance. They are capable of independent replication.

PROTOZOOLOGY: A branch of biology, which deals with the protozoa.

PSEUDOPODIA: Is a complex infrastructure of microtubules**,** microfilaments and other organelles associated with cytoplasmic protrusion used for locomotion and or feeding in protozoa.

SPORE: A reproductive cell that develops into a new organism without the need to fuse with another reproductive cell.

TITER: The titer of the virus, or the endpoint, is the dilution at which 50% of the inoculated hosts are infected (infective dose; **ID50**) or killed (lethal dose; **LD50**).

TROPHOZOITE: A stage of development in protozoa in which the organism is said to be mature and therefore active or able to feed.

VIRION: A virus particle when it is on the outside of its host cell, and consists of either DNA or RNA surrounded by a protective cover called capsid.

XII. Compiled List of Compulsory Readings

Compulsory Reading # 1

Title: Microscopy

URL: http://en.wikipedia.org/wiki/Microscopy

Abstract: Here you will find a description of the optical microscopy techniques such as the bright field, oblique illumination, dark field, phase contrast, differential interference contrast, and other related information. It includes a description of other types of microscopy such as the electron and scanning probe microscopes.

Rationale: Microbes are too small to be seen by the unaided eye Therefore the study of microbes requires knowledge of the use of tools like a microscope or other magnifying instruments in order to appreciate the world of microbes.

Compulsory Reading # 2

Title: Microbiology and Bacteriology

URL: http://en.wikipendia.org/wiki/Bacteria

Abstract: Through this link, you will find an online textbook with chapters which deal with different aspects of the biology of bacteria. The book includes topics on classification and identification and the significance of microbes in biotechnology and industry.

Rationale: By making use of this link, you will be able to appreciate how bacteria were discovered, to learn about their diversity and biology. Given this knowledge you will then be able to rationalize the role of bacteria in the environment and industry.

Compulsory Reading # 3

Title: Microbiology 102 Home Page

URL: http://en.wikipedia.org/wiki/Bacterial_growth

http://en.wikipedia.org/wiki/Microbial_metabolism

Description: These links take you to an online book of microbiology. From the table of contents of this book, you will be able to get knowledge on three relevant topics in bacteriology, namely: (a) Bacterial Growth http://en.wikipedia.org/wiki/Bacterial_growth (b) Bacterial Nutrition (sources of energy, nitrogen, carbon, oxygen, etc), and (c) Environmental Requirements for Microbes.

Rationale: The links will enable you accomplish part of the learning objectives in the module; it is about bacterial nutrition, growth and environmental requirements for growth.

Compulsory Reading # 4

Title: Laboratory Techniques

URL: http://en.wikipedia.org/wiki/Category:Laboratory_techniques

Abstract: This website will take you to a list of laboratory techniques which are commonly used in microbiology. Click on the technique you wish to look up and that website will take you to the link where the details of that technique are given.

Rationale: A prerequisite to the satisfactory study of microorganisms is their cultivation under laboratory conditions; and in order to accomplish this, one must know some techniques, particularly those that will enable the learner to study and manipulate microorganisms in the laboratory away from their natural habitat.

Compulsory Reading # 5

Title: Viruses

URL: http://en.wikipedia.org/wiki/Virus#Discovery

Abstract: This link introduces another group of microbes, the viruses. It provides the basic reading material on viruses; going as far as describing their discovery, origins, classification, structure, replication, life forms, viruses and disease to include epidemics, detection, purification and diagnosis, prevention and treatment, potential uses in therapy and their applications.

Rationale: It has an extensive coverage on the part of virology.

Compulsory Reading # 6

Title: Protozoa

URL: http://en.wikipedia.org/wiki/Protozoa
http://en.wikipedia.org/wiki/Flagellate
http://en.wikipedia.org/wiki/Amoeboid
http://en.wikipedia.org/wiki/Sporozoans
http://en.wikipedia.org/wiki/Coccidia
http://www.tulane.edu/~wiser/protozoology/notes/intes.html

Abstract: These website references should be read together in order to have overview knowledge about protozoa. Each web reference deals with a specific group of protozoa explaining the classification and describing their biology. The significance of protozoa is also discussed emphasizing their medical impact on human health.

Rationale: The morphology and structure of the protozoa are well illustrated making the descriptive text easy to follow. The life cycles of some protozoa are amply illustrated in the following web reference: http://www.tulane.edu/~wiser/protozoology/notes/intes.html

Compulsory Reading # 7

Title: Fungi

URL: http://en.wikipedia.org/wiki/Fungus

Abstract: The link is packed with basics on fungi, which includes their characteristics (morphologies, spores, etc.), fossil records and phylogenetic relationships. Detailed descriptions of each of the major groups of fungi is covered.

Rationale: The link is a good introductory text on the study of fungi. It also has the latest classification of the fungi based on the molecular approach.

XIII. Compiled List of (Optional) Multimedia Resources

Resource # 1

Title: The Big Picture Book of Viruses

URL: http://www.virology.net/Big_Virology/BVHomePage.html

Abstract: This link takes you to The Big Picture Book of Viruses which is intended to serve as both a catalogue of virus pictures on the internet and as educational resource to those seeking more information about viruses. It is also linked to All the Virology on the WWW, and or collection of Virology Courses and Tutorials.

Rationale: It has an extensive coverage of the structure of viruses and their taxonomic groupings are given. A wide range of sources have been brought together in this book.

XIV. Compiled List of Useful Links

Useful Link # 1

Title: Todar's Online Textbook of Bacteriology

URL: http://www.textbookofbacteriology.net/

Abstract: This link takes you to an online textbook whose contents are suitable for general microbiology. It also covers relevant aspects of medical bacteriology with specific examples of disease causing agents.

Rationale: It is important to widen your horizons on microbiology with an online textbook that is at the cutting edge of knowledge in microbiology.

Useful Link # 2

Title: Bacteriology Techniques

URL: http://en.wikipedia.org/wiki/Category:Bacteriology_techniques

Abstract: This website will take you to a list of bacteriological techniques which are commonly used in microbiology. Click on the technique you wish to look up and that website will take you to the website where the details of that technique are given.

Rationale: A prerequisite to the satisfactory study of microorganisms is their cultivation under laboratory conditions; and in order to accomplish this, one must know some techniques, particularly those that will enable the learner to study and manipulate microorganisms in the laboratory.

Useful Link # 3

Title*:* Malaria

URL: http://www.who.int/mediacentre/factsheets/fs094/en/

Abstract: This is a World Health Organization site which harbours updated information on malaria. It defines what malaria is, the situation in Africa, its effects during pregnancy, treatments and economic costs due to malaria.

Rationale: You should have noted so far that parasitic protozoans are able to survive successfully and reproduce in almost all animal species. As such, protozoa are a remarkably successful group of organisms that have evolved complex and closely integrated relationships with their hosts. The study of *Plasmodium* spp. which causes malaria, is a case example.

Useful Link # 4

Title: Microbiology and Immunology

URL: http://pathmicro.med.sc.edu/mycology/mycology-1.htm

Abstract: It is an online study material of the University of South Carolina School of Medicine. Chapter one of this mycology course covers the classification of fungi, morphology, important fungal diseases including diagnosis and treatment.

Rationale: Knowledge of fungi as they affect human beings is important because it brings closer home the negative effects of fungi on the health of humans and ultimately how this can affect the national economy. Therefore, knowledge of some fungal infections in terms of their etiology, pathology, diagnosis and treatments is necessary for a mycology student.

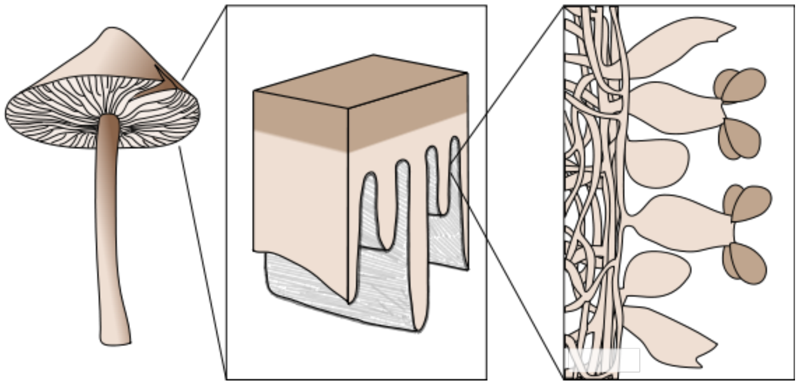
Useful Link # 5

Title: Mycological Resources on the Internet: Resources for Teaching

URL: http://mycology.cornell.edu/fteach.html

Abstract: It is a very rich source of different aspects of Mycology. Various topics are covered. You will need to identify a particular topic and follow it up with the links provided.

Rationale: It is important to know the classification of fungi, their structure and types of associations, reproduction, ecological requirement and the usefulness of fungi. These are the aspects covered by the various links, including mushroom cultivation.



Schematic representation of a basidium, the fruiting structure of a Basidiomycota

http://en.wikipedia.org/wiki/Image:Basidium_schematic.svg
Accessed on 8/4/2008

XV. Synthesis of the Module

This is a module about microbes. They are too small in size that it is necessary to use a microscope to see them. A study of such organisms is called microbiology. It includes organisms such as bacteria, protozoa, and fungi. Although viruses are strictly not organisms but particulate matters that become active once they are inside a host cell, they too, are considered to be microbes for convenience. Micro-organisms are important to human beings because they have a direct effect on **animal** (including human) **and plant health**, **food and beverage production** and keeping the ecosystem in a stable state. Therefore an understanding of their biology is useful so that they can be efficiently exploited and controlled. The biology of the organisms includes their **morphology** and **structure**, **growth** and **development**, **nutrition**, **respiration** and **reproduction**. It is also important to study their **taxonomy** and to be able to **identify** them. In order to study microorganism it is important to be familiar with the **aseptic technique**, and to be able to prepare **growth media** on which to **culture** the organisms.

XVI. Summative Evaluation

As a requirement for the completion of this module, you will be examined using a testing instrument, which will be made up of questions of various types. The questions will test your ability to recall information you have learned in the module, others will test your comprehension of various concepts dealt with and yet others will test your ability to analyse given data and or to evaluate and apply it. The design of questions will vary within a paper. There will be a few multiple choice type questions, others will be in the form of short answer questions and yet others will be descriptive and explanations of concepts.

The following are a sample of the type of questions that are expected.

1. Which of the following cell types are not micro-organisms?

   A red blood cells
   B. protozoa
   C. yeasts
   D. archaea

2. Growth of mold is favoured by …

   A. acidic conditions.
   B. aerobic conditions.
   C. presence of moisture.
   D. all of the above.

3. Brewers/bakers yeast is important for…..

   A. commercial alcohol brewing.
   B. leavening of bread.
   C. experiments in the human genome project.
   D. acid production.

4. The highly-resistant ‘resting cells’ produced by *Bacillus* and *Clostridium* are called…..

   A. reproductive spores.
   B. seeds.
   C. endospores.
   D. vegetative cells.

5. The genetic material of bacteria is composed of….

   A. ATP
   B. DNA
   C. ribosomes
   D. protein

6. Give the meaning to each of the following terms.
   - A. Trophozoite
   - B. Chemostat
   - C. Capsid
   - D. Merozoite
   - E. Antheridium

7. Write short answers to the following questions:
   - A. Describe the two basic mechanisms that produce genetic change in bacteria?
   - B. List the three most common cellular morphologies in clinically significan bacteria.
   - C. Explain the economic significance of protozoa.
   - D. Explain the mode of nutrition in fungi.
   - E. List the characteristics common to all the viruses.

8. Compare and contrast between the following terms.
   - A. Eukaryotic and prokaryotic cells.
   - B. Lichens and mycorhizae.
   - D. Heterokaryosis and dikaryotic conditions
   - E. The importance of protozoa and that of viruses

9. A. State the classification of protozoa.
   B. indicate under each category the characteristics peculiar to that group of organisms.

10. A. Outline the steps involved in the lytic life cycle of a virus using the bacteriophage as an example.
    B. Provide an explanation for each stage cited.

11. A. Draw the structure of *Escherichia coli*.
    B. Label the cytoplasmic contents of the cell.

12. Outline the characteristics of the sub-divisions of fungi given below. Basidiomycota, Ascomycota, Zygomycota, Oomycota, and Deuteromycota.

13. Explain the steps involved in adenovirus DNA replication.

14. A. Describe the classification of protozoa.
    B. Identify the disease-causing genera of protozoa
    C. List the causal agents in each case.

15. Explain the economic significance of fungi in an ecosystem.

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XVIII. Main Author of the Module

Principal Author of the Module

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